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MEANINGFULNESS, FREQUENCY, AND AFFECTIVE CHARACTER OF WORDS AS RELATED TO VISUAL DURATION THRESHOLD

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A RECENT STUDY (Johnson, Thomson, & Frincke, 1960) has shown that words matched in Thorndike-Lorge (1944) frequency, varying in goodness as goodness is measured by the good-bad scale of the semantic differential, are correctly reported at significantly different visual duration thresholds (VDT) in tachistoscopic presentation. Good words are reported by subjects at significantly lower thresholds than are bad words. These results revive some of the seemingly resolved issues surrounding the question of perceptual selectivity.

If this goodness variable does indeed influence the probability of obtaining correct reports of visual stimuli at different lengths of exposure, it is of some theoretical importance to determine the underlying basis of its influence on VDT. An obviously significant characteristic of words that was not controlled in the original VDT study is that of meaning or meaningfulness (which we shall denote as *m*) as introduced by Noble (1952a). Noble has proposed as a measure of *m* the mean number of associations (excluding clang and certain other categories of association) a word can evoke from subjects in a fixed time interval. The *m* of a word is known to be related to rate of learning (e.g., Noble, 1952b) and to VDT (Kristofferson, 1957). The *m* and the frequency of words are closely related however (Underwood, 1959), and studies in this area have not controlled for this relation. Meaningfulness is also related to the emotionality associated with dissyllables (Noble, 1958). These results suggest the possibility that frequency, *m*, and goodness may all co-vary. The first experiment reported here was designed to determine whether a relation exists between goodness and *m* with frequency held constant.

EXPERIMENT I

In their VDT study Johnson, *et al.* (1960), used nine pairs of good *versus* bad words, all of a Thorndike-Lorge G count of 12, 13, or 14. These words, along with sixteen other words used by Johnson, *et al.* in a second VDT experiment, were presented to 23 naïve San Jose State College Ss in order to determine their *m* values. Since we wished to control for frequency, we used only those eighteen words of 12, 13, or 14 G count frequency in our analysis. Noble's (1952a) instructions were used and his scoring procedure was followed as closely as possible. The 34 words were presented to Ss on four dittoed sheets with eight words on two sheets, nine words on the other two. The sheets were folded so that only one word appeared at a time. The

mean number of associations to each of the words was obtained. The same words were presented later, in the same fashion, to 79 University of California (Berkeley) Ss, and mean m values were obtained for this sample population. The VDTs of the words (from Johnson, *et al.*, 1960) and the m values obtained for these words from each of the two m production groups are presented in Table I.

TABLE I

m AND THRESHOLDS* OF GOOD AND BAD WORDS MATCHED IN FREQUENCY

Good words	(San Jose) Freq.	(Berkeley) m	m	VDT	Bad words	(San Jose) Freq.	(Berkeley) m	m	VDT
Rally	12	8.46	7.65	.1092	Stammer	12	6.48	5.95	.1538
Glisten	13	8.73	7.96	.0777	Corrupt	12	7.04	7.46	.0985
Prosper	13	6.84	7.48	.1046	Defect	14	6.51	6.67	.0815
Ivory	13	9.87	9.05	.0262	Hinder	13	5.63	5.77	.0969
Ginger	13	8.71	7.92	.0446	Wretch	12	6.48	5.53	.1285
Alert	14	7.72	7.39	.0392	Scandal	13	7.93	6.67	.1123
Vehicle	13	10.54	8.86	.0492	Dismal	13	6.86	7.35	.1162
Caress	12	7.72	8.09	.1085	Penalty	13	7.43	7.09	.0469

*From Johnson, *et al.*, 1960.

Mann Whitney summed ranks tests show that each of the two samples produced significantly ($p = < .005$) higher m values for good than for bad words. The rho between m produced by these two samples of *Ss* is $+ .84$ ($p < .01$). Much of the variance in VDT both within the groups of good and bad words and between good and bad words seems related to variation in m. In order to determine the influence of m, goodness, and of frequency on response measures, it seemed essential to vary each of these three variables while controlling the other (co-varying) two. We attempted this in Experiment II.

EXPERIMENT II

Although m, frequency, and goodness all co-vary, the relation is not a perfect one. Three rather large samples of words exist for which m values are available; Noble's 96 words and paralogs, the 34 words for which we had m values obtained in Experiment I, and an unpublished list of 96 words for which m values had been obtained by Postman (1960). Sixteen pairs of words matched in frequency, varying in m, eight pairs of words varying in goodness, matched in both frequency and m, and sixteen pairs of words varying in frequency, matched in m were obtained from the three lists of words of known m value. Both members of each pair were always selected from the same one of the three lists of m values noted above (and words whose m values were obtained in Experiment I were matched in m from the responses of the San Jose sample, since the Berkeley m values had not yet been calculated). It would have been highly desirable to match the frequent-infrequent and the high m–low m word pairs in goodness. Since goodness, frequency, and m are substantially related, it was impossible, with the available words of known goodness and known m, to control completely for goodness in the "frequency varied, matched m" and the "m varied, matched frequency" lists. The *Es* did attempt to keep these lists matched as closely as

possible in goodness, by introducing the best available words into the low *m* and low frequency lists. Forty-one *Ss* were presented with the 32 pairs of words of the frequency and *m* lists and asked to "encircle the most pleasantly toned word of each pair." The majority of *Ss* chose two low *m* words (preview and wisdom) as better than their high *m* matches and chose six low frequency words (vertex, argon, mermaid, stanza, oxide, and lotion) over their matched high frequency words. High *m* words have a decided advantage over low *m* words and high frequency words a lesser advantage over low frequency words along the goodness dimension.

The *Es* wished to determine the influence of *m*, frequency, and goodness on VDT. The words described above were put on slides in the form of bold face capital letters. In the process, however, the artist made an error that the *Es* did not catch in time, so that it was necessary to eliminate one good-bad word pair leaving only seven pairs of good-bad words, matched in G count frequency and in *m*. Seventeen introductory psychology students, none of whom had taken part in any previous psychological experiments, served as *Ss* in the presentation of seven pairs of good-bad words matched in frequency and *m*, and of eight pairs each of frequent-infrequent words matched in *m* and of high and low *m* words matched in frequency. These words were presented to *Ss* through a Revere 888 tachistoscope. Each *S* sat 18 ft. from the screen upon which the words were projected. The testing room was fully illuminated while the tachistoscope was used at the smallest possible lens opening. The ratio of room illumination to screen illumination was 1:1.19. The words were presented in different random order to each *S*. A modified method of limits was used in which the list of words was presented at 1/50, 1/25, 1/10, 1/2, and 1 sec.

Each subject's mean VDT was obtained for each of the six groups of words. Fourteen of the seventeen subjects had lower mean VDTs for high than for low *m* words matched in frequency. A sign test reveals this difference to be significant ($p < .05$). Sixteen of seventeen subjects had lower mean thresholds for good than for bad words matched in *m* and in frequency, a significant difference ($p < .01$). Twelve of seventeen subjects had lower mean thresholds for frequent than for infrequent words matched in *m*, a difference that does not reach significance. When analysing by mean thresholds of words, rather than by thresholds of subjects, Wilcoxon signed ranks tests show that high *m* words are reported at significantly ($p < .05$) lower thresholds than low *m* words of the same frequency and good words at significantly ($p < .05$) lower thresholds than bad words of the same frequency and *m*, while no significant relation exists between frequency and VDT when frequent and infrequent words are matched in *m*. The words used in the VDT study reported above, as well as the words used in the partial replication reported below, are presented in Table II.

The remaining eight pairs of words matched in frequency varying in *m*, and matched in *m* varying in frequency, were presented to eighteen other subjects, none of whom had taken part in any previous experiments, under the same conditions described above. One condition varied between the original and this partial replication. Room illumination was

TABLE II

WORDS USED* IN THE TACHISTOSCOPIC EXPERIMENT

Words matched in L count freq., varying in *m*						Words matched in G count freq. and in *m*, varying in goodness				Words matched in *m*, varying in freq. (Sample 1, G Cnt.) (Sample 2, L Cnt.)					
High *m*			Low *m*			Good		Bad		Frequent			Infrequent		
Word	*m*	VDT	Word	*m*	VDT	Word	VDT	Word	VDT	Word	VDT		Word	VDT	
Sample 1															
Circus	11.21	.0224	Device	6.84	.0524	Prosper	.0794	Dismal	.0918	Heaven	.0376		Jelly	.0306	
Tennis	12.36	.1435	Presence	6.28	.2147	Kitchen	.0406	Army	.0559	Village	.0212		Zebra	.0435	
Country	10.65	.0371	Moment	7.39	.0859	Jewel	.0435	Insect	.1041	Captain	.0371		Typhoon	.0847	
Garden	12.01	.0659	Reason	7.17	.0553	Zenith	.0506	Ordeal	.0506	Uncle	.0318		Youngster	.0712	
Cinder	9.65	.1188	Fetish	5.70	.1800	Income	.0488	Hunger	.0988	Leader	.0341		Mallet	.0959	
Skillet	10.22	.1224	Relic	7.95	.0894	Bodice	.0894	Pallor	.1435	Effort	.0541		Unit	.0529	
Mermaid	10.01	.1071	Abbess	4.71	.4165	Zebra	.0435	Typhoon	.0847	Lichens	.2394		Vertex	.0582	
Curfew	8.60	.1012	Pestle	5.52	.2818					Sequence	.1224		Argon	.0441	
										Word	*m*	VDT	Word	*m*	VDT
Sample 2															
Tortoise	9.18	.1189	Gullet	5.94	.2222					Leather	10.16	.1089	Mermaid	10.01	.0922
Oboe	8.48	.2144	Dotage	5.01	.2522					Order	8.33	.1122	Stanza	8.36	.1122
Carbon	9.31	.0856	Preview	6.66	.1744					Trouble	7.76	.1211	Oxide	7.69	.0689
Hermit	8.50	.1333	Magnate	6.86	.3789					Figure	9.05	.0944	Lotion	9.06	.1144
Forest	11.26	.1056	Belief	7.18	.2567					Belief	7.18	.2567	Bramble	7.04	.4967
Biscuit	10.40	.1556	Wisdom	7.88	.1544					Placard	6.80	.4656	Wicket	6.90	.2867
Morning	10.30	.0789	Answer	8.37	.0633					Welfare	7.70	.0689	Decoy	7.59	.1367
Color	10.99	.1044	Order	8.33	.1122					Answer	8.37	.0633	Burlap	8.40	.1056

*Frequencies are not presented, since they are widely available in the Thorndike-Lorge tables. The frequency measure of the words from Postman's unpublished *m* study is L count, since he used this count. Words used by Johnson, *et al.* (1960) for which *m* values were obtained in Experiment I, and words from Noble's (1952) list are matched in G count frequency since this count has been used in considerable previous work with these words. *m* values obtained from Noble (1952) are not included in this table since they are already available in published form. *m* values for words from Postman's list are presented, since they have not yet been published.

greater in the original experiment. One tachistoscope broke down midway through this replication, and the second tachistocope projected more light on the screen. For these reasons, room illumination to screen illumination ratio varied between 1:1.08 to 1:1.23 for various subjects. Illumination remained constant for any one subject, however.

Each subject's mean VDT was obtained for each of the four lists of words. Sixteen of the eighteen subjects had lower mean thresholds for high than for low *m* words matched in frequency. A sign test reveals this difference to be significant ($p < .01$). Eleven of the eighteen subjects reported high frequency words at lower mean thresholds than low frequency words, matched in *m*. This difference is not significant. When analysing by words, rather than by subjects, using Wilcoxon signed ranks tests, high *m* words have significantly lower VDTs than low *m* words matched in frequency ($p < .02$), while frequent and infrequent words, matched in *m*, do not differ significantly in threshold.

Discussion

We can say with assurance as a result of Experiment I, that good words have higher *m* values than have bad words of the same Thorndike-Lorge frequency. This fact led us to believe that the lower thresholds of good words as compared with bad words previously reported (Johnson, *et al.*, 1960) resulted from uncontrolled variation between good and bad words in *m*.

We had originally hoped that we could account for the relation obtained earlier between word goodness and threshold by controlling the variable of meaningfulness. While *m* and goodness are related, differences in threshold persist even when good and bad words are matched in *m*. The question of why word goodness is related to threshold was not answered in these experiments.

Experiment II revealed no relation between frequency and threshold, once the co-varying *m* was controlled. Goodness, as a variable, was not too adequately controlled in this matched *m*, varied frequency list. If we look at the goodness of these words, disregarding frequency, we find that eleven good and four bad words had the lower thresholds of their respective pairs. High *m* words were reported at lower thresholds than low *m* words matched in frequency. High *m* words are generally rated as affectively better. High *m* words are also generally concrete (have a physical referent) and high in imagery while low *m* words are abstract (do not have a physical referent) and lacking in imagery. Since these stimulus characteristics vary along with *m*, we cannot attribute differences in threshold between high and low *m* words solely to differences in *m*. The results do demonstrate, however, that *m* is a variable influencing response

probability even with frequency controlled. Meaningfulness, as a variable, seems most influential at low frequency levels.

Variables influential in producing variation in visual duration threshold presumably are also influential in determining response probability in serial and paired associate verbal learning (Cohn, 1954). If our findings have generality, then traditional explanations of verbal learning require re-examination concerning the variables directly influential on learning and on VDT. Our findings suggest that frequency, *per se*, is of little influence. Because frequency is closely related to those variables that are influential, it does, however, serve as a relatively adequate predictor of rate of learning and of VDT.

Summary

Good words, matched in frequency to bad words, have higher meaningfulness (*m*). Lists of words varying in *m*, matched in frequency; varying in goodness, matched in *m* and frequency; and matched in frequency, varying in *m*, were used in VDT experiments. Word goodness was clearly related, *m* possibly related, and frequency essentially unrelated to visual duration threshold.

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THE ROLE OF FREQUENCY IN DEVELOPING PERCEPTUAL SETS

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FOR MANY YEARS the construct of set has been used to demonstrate how we perceive or respond to a situation in terms of our past experience. Every beginning psychology student hears about the varying responses of the farmer, boy scout, artist, and engineer to the running brook. While the proposition alluded to is generally accepted, there is actually very little pertinent research relating the amount of past experience to perception. The only work done has made use of relatively simple diagrams or ambiguous figures (Leeper, 1935; Rock & Kremen, 1957; Binder & Feldman 1960). While Leeper did find that he could control his subjects' responses by manipulating past experiences, he did not attempt to demonstrate any systematic or quantitative relationship between amount of experience and response; he was more concerned with *kind* of experience, that is, whether the subjects were shown a simplified copy of the ambiguous figure with one of the interpretations emphasized or whether they were also told what to look for. Schafer and Murphy (1943) have tried to demonstrate that a particular profile can be made to dominate a composite figure involving two profiles if it is first shown alone and the subjects are reinforced for responding in a specific manner. While their experiment has not been successfully replicated, it does not bear directly on the question concerning us here because no relation was shown between amounts of past experience and response.

Despite the lack of direct support, Allport (1955) has postulated that perceptual sets are basically determined by past experience and the greater the *frequency* of such experiences, the stronger the set. Epstein and Rock (1960) found recency to be more potent than frequency or expectation in the perception of an ambiguous figure, and argue that a distinction should be made between total past experience and current factors in the immediate situation (recency). The experiment, however, did not deal with a new perception. Their subjects had already been familiarized with the alternative percepts. The present experiment deals with an attempt to observe the possible relation between the strength of a set and the frequency of set-inducing experiences. It makes use of an ambiguous figure[2] which appears to have some advantages over other

[1]Now at Far Eastern University, Manila, Philippines.

[2]The figure was originally prepared to illustrate the bias of some psychologists who view men as rats or vice versa.

such figures that have been offered for the entertainment of psychologists in the past.

FIGURE 1. The rat-man ambiguous figure used in this study.

It can be perceived as belonging to either of two cognitive categories or classes or objects: animals and humans. Thus the figure can be seen as either a rat or an old man. It is possible to induce either response by showing the viewer pictures of other animals or of people without any further instruction. Thus, if we want a subject to "see" a "rat," we merely show him pictures of a dog, cat, etc.; if we want a response of "old man," we show pictures of children, men, women, etc. Although our experiment makes use of an ambiguous figure, it should be clear that we are not suggesting that the study is directly concerned with perception except in the limited sense of perception of diagrammatic pictures (Gibson, 1951). It appears appropriate to indicate that our findings might have more bearing on what might be termed "cognitive" sets rather than on perceptual sets. The term "perceptual" set might better be reserved for reference to those instances where a subject is looking for or expecting to see a specific stimulus, a friend's face in a crowd, for example, or a particular colour of book cover on a shelf.

The experimental design involved presenting a varying number of set-inducing experiences before testing with the ambiguous figure. Assuming, with Allport, that having different numbers of such experiences would result in different strengths of set, it was also decided to test for such strength by attempting to induce the alternate set in the several groups

of subjects. The presumption here is that those with a strong set will resist such new set induction more than those with a weak set. While not completely free from the influence of other variables the procedure followed offers some observations on the strength of sets as a function of frequency.

Method

Materials

The ambiguous figure shown in Figure 1 was drawn on an 8 x 11 in. white cardboard and simple cartoon drawings of humans and animals were similarly prepared. A human series consisted of a sketch of a baby, an old woman, a young boy, a young girl, an adult man, an adult woman. The animal series consisted of drawings of a rooster, duck, fish, rabbit, dog, and cat.[3] Each of the figures occupied about a 5-in. square and was easily seen in an average classroom. The human figures were drawn as heads only; the animal figures were body outlines with a few details sketched in.

Procedure

Groups of Ss were first told that the experimenter wished to test the suitability of various drawings for future use in a tachistoscopic experiment and wanted to be sure that the drawings were readily recognizable. He then asked the Ss to describe the pictures to be shown by writing "a word or two" and proceeded to hold up the first drawing, exposing it for approximately five seconds with the inquiry as to whether everyone had a good view and a good look. The time proved sufficient and it might be noted here that all Ss identified all of the items in the series with no difficulty. For half of the group the human series was shown first with 1, 2, 3, or 4 pictures offered for inspection. Without any pause the ambiguous figure was then shown, and again without pause the animal series was exposed, with all six animal pictures shown. The ambiguous figure was shown again at the end of the animal series. For the other half of the groups, 1, 2, 3, or 4 animal pictures were shown before the ambiguous figure and this was followed in all cases with the six human figures with the ambiguous figure again being shown last.

Subjects

The twelve groups of Ss were all members of discussion sections in the beginning course in psychology, both men and women in about equal proportions. It should be noted that when the ambiguous figure was exposed to a similar group of students in a history class, 81 per cent of 45 Ss identified the drawing as a "man" when no preliminary instructions were given beyond asking the students to write down what they thought the picture represented.

Results

The basic findings are presented in Table I. The most striking observation was that with only one prior experience, a picture of a cat, or a lady,

[3]From control studies it appears that the order of presentation of these pictures has no bearing on the results. Copies of these pictures are available from the authors.

groups of subjects can be led to describe the ambiguous figure as a "rat" or a "man," respectively, in about 75 per cent of the cases. This may not be so surprising in the case of the "man" interpretation as we have pointed out that, without any attempt at inducing a set, a history class responded with 81 per cent of "man" answers. To find that only one animal picture can alter such a percept to a "rat" interpretation is strong evidence for the judgment that such sets are readily induced, requiring only what amounts to a slight hint. The difference in the choices of the groups is significant beyond all normal statistical requirements. When subjects are shown more than one set-inducing picture the number who report the ambiguous figure in line with the set is increased, although not so clearly in the human groups except for those who were shown four human pictures. The animal set shows a more regular progression in percentage of reports so that with four animal pictures almost everyone reports a rat. In fact, not to see a rat might be grounds for consideration of the operation of some other influence such as some suspicion of the procedure or expectancy of a trick on the part of the experimenter.

TABLE I

THE ORDER OF PRESENTATION OF SET-INDUCING PICTURES AND THE PER CENT OF MAN OR RAT RESPONSES TO THE AMBIGUOUS FIGURE

Group	*N*	Pictures seen	Per cent man	Per cent rat	Set-breaking pictures	Per cent man	Per cent rat
I*	42	B**G–M–W	88	12	R_1–R–D–C	78	22
II	16	B–G–M–W	75	25	F–R_1–R–D–C	75	25
III	20	B–G–M–W	80	20	D_1–F–R_1–R–D–C	80	20
IV	45	G–M–W	73	27	D_1–F–R_1–R–D–C	66	34
V	47	M–W	75	25	D_1–F–R_1–R–D–C	71	29
VI	33	W	73	27	D_1–F–R_1–R–D–C	63	37
VII	59	R_1–R–D–C	3	97	B–G–M–W	3	97
VIII	14	R_1–R–D–C	22	78	O–B–G–M–W	29	71
IX	19	R_1–R–D–C	0	100	B_1–O–B–G–M–W	6	94
X	48	R–D–C	9	91	B_1–O–B–G–M–W	13	85
XI	39	D–C	18	82	B_1–O–B–G–M–W	26	74
XII	27	C	26	74	B_1–O–B–G–M–W	33	67

*Groups I–III had the same preliminary exposures of four human pictures; Groups VII–IX had the same animal pictures shown first.

**Code: B—boy, G—girl, M—man, W—woman, O—old lady, B_1—baby, R_1—rooster, R—rabbit, D_1—duck, F—fish, D—dog, C—cat.

It will be recalled that after the ambiguous figure was shown, the experimenter continued to show pictures of the other class (animals following humans, and vice versa). This was done to discover if the first set could be broken or "extinguished." All groups were shown all six pictures of the new category and the ambiguous figure was then shown again. It was expected that those groups that had seen only one or two pictures of

a given category in the first instance would not retain the set as well as those shown three or four such pictures. The general finding here was that while in most instances fewer people retained the original set, in most cases there was not a significant loss of this original set. The only group that showed a significant loss was the group that had seen only one human figure in the original series. A significantly different number of these subjects was induced to adopt a rat set by the subsequent showing of the animal series. A new group ($N = 56$) was added to the experiment to test for the possibility that the two series of pictures were shown in too rapid a sequence. This group was shown a picture of a woman, followed by the ambiguous figure. Seventy-one per cent responded with "man." After a half hour, during which a lecture was given, the experimenter stated that he had some more pictures to check and he now showed the animal series of six pictures and followed these with the ambiguous figure. This time only 45 per cent responded with "man," a significant difference.

Discussion

The experimental findings lead to the confident conclusion that a majority of an academic population in a classroom setting can be made to see whichever of two interpretations an experimenter chooses to impose on the group. This clear-cut demonstration might be useful in introducing classes to discussions of the concept of set. The interpretation of the findings is by no means as clear-cut as the statistical result. While it is apparently the case that probably 85 to 95 per cent of students in psychology classes can be made to see a man or a rat at the whim of the instructor by showing as few as four set-inducing pictures we cannot argue from the results that such sets are actually learned as a function of frequency. The fact is that approximately 75 per cent of the people will respond in accordance with the desired set after seeing only one picture of a given class. Adding more pictures does mean adding more people, but this does not necessarily mean that the later arrivals were slowly acquiring a set. They may not have instructed themselves to label the pictures as members of a class until after they had seen several. Once the label had been attached, the set may have become operative in one trial. The fact that it was not easy to break the sets by showing pictures of another class suggests that once a given set is adopted, the subjects either retain it, or develop new sets such as expecting successive classes of pictures, so that they do not adopt the second set as something to follow implicitly. When the ambiguous figure is shown the second time, the subjects commonly report "We've seen that one" and offer the former identification even though they may not have exactly the same percept.

When a time factor is interposed it may be that the original set is not so much broken as replaced. The subjects now are free to develop a new set and appear to do so.

The present results suggest that such perceptual sets are easily imposed, perhaps in a one-trial learning operation, and that they have an all or none quality at least over a short span of time. They are not readily broken by immediately interposing new experiences. In general, then, the present results offer only little support for the frequency proposition that Allport postulates, at least with respect to such "cognitive" sets. Like much other meaningful learning it appears to be possible to acquire the necessary adjustment in one trial. It may be that other kinds of sets are much more regularly dependent upon the number of previous experiences but our data appear to support the conclusion that when previous experience has already prepared the subject with such labels as "animal" or "human," he can readily attach such labels to a specific situation very quickly.

While the present procedure deals ostensibly with a problem in perception, it may more properly be classified in the area of cognitive activity as should many other researches that have made use of sets. It may well be that perceptual factors are involved in responding to such ambiguous or any other figures or pictures. The cognitive identification of a class of objects or procedures such as is made in arithmetical operations or in solving anagrams that have some classifiable method of solution is, however, not to be ignored. Our subjects, for example, did not expect to see a rat or an old man just prior to viewing the ambiguous figure. They expected, if anything, to see some animal—it might have been a tiger or an elephant, or, in the case of the human set, another representative of the species. Even when the subjects are shown a series of letters or numbers with one of these distorted to appear as either a B or 13 as was done by Bruner and Minturn (1955), we cannot argue that the subjects were set to perceive that particular visual stimulus; they were cognitively set to perceive a B, or 13, regardless of its physical stimulus aspects.

Summary

The hypothesis that frequency of experience determines the strength of a set was investigated. A novel ambiguous figure which could be perceived as either a rat or a man was used as the test item. Sets were established by first showing a series of sketches of animals or people. Extinction of the set was also attempted. Results show that such sets are quickly established, probably in one trial, and are not easily broken. No striking relationship between frequency of experience and strength of set was revealed. While the use of a picture suggests that the set is perceptual, analysis of the findings supports the hypothesis that the set involved is more logically to be considered as "cognitive."

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THE EFFECT OF CONTRALATERAL VISUAL STIMULATION ON VISIBILITY WITH STABILIZED RETINAL IMAGES[1]

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WHEN A SIMPLE LINE DRAWING is viewed in the stabilized condition, a remarkable sequence of events takes place. The visual object vanishes either as a whole or, less often, in parts; then after a short period reappears intermittently. When a complex figure is viewed in a stabilized condition, the tendency for it to break up increases, its parts disappearing and reappearing independently (Pritchard, Heron & Hebb, 1960). The phenomenon depends on the immobility of the locus of retinal stimulation (that is, on preventing the retinal effects of "physiological nystagmus"); the image can be restored to vision by experimentally controlled movements (Ditchburn, Fender, & Mayne, 1959; Krauskopf, 1957). Vision is also maintained longer when the illumination is intermittent (Cornsweet, 1956; Ditchburn & Fender, 1955; Pritchard, 1958).

A theoretically more interesting result from a psychological point of view, however, is the fact that the frequency of disappearance is reduced by concurrent stimulation of other senses. The introduction of a continuous tone or noise results in a higher level of visibility (Pritchard, 1958; Pritchard & Vowles, 1961). A bitter stimulus on the tongue is said to have restored a figure which had disappeared.[2] These results suggest that the level of arousal is a factor in the maintenance of vision under these conditions.

There is some indication that the structure of the stabilized object itself can determine its visibility; that is, one part of a figure can determine the visibility of other parts of the same figure. This has been noted most frequently in figures which contain parallel lines (Pritchard, Heron, & Hebb, 1960). In this case, the lines tend to disappear and reappear together.

The results mentioned above were obtained monocularly; there is, however, some evidence of binocular interaction (Krauskopf & Riggs, 1959; Ditchburn & Pritchard, 1960). The object of the present study is to obtain more detailed information on the manner in which stimulation of the contralateral retina affects the visibility of the stabilized image.

[1]I wish to acknowledge invaluable assistance from The Myron R. Haugen Contact Lens and from Fred J. Kader, McGill University. This study was primarily supported by the Defence Research Board (9401-11), with aid also from the National Research Council of Canada (AP 17) and the U.S. Public Health Service (M-2455).

[2]Personal communication to R. M. Pritchard from S. Mayne-Rymes.

In a preliminary study, patterned light, diffused light, and no light at all were presented to one eye, while the other viewed a stabilized image. In a second experiment one eye viewed a straight vertical line stabilized, while a similar line was presented to the other eye unstabilized. The subject saw the two lines as parallel to each other. The purpose was to examine the effect of experimentally varying the apparent distance between the two lines.

METHOD

S wore a tight-fitting contact lens on his right eye; a collimating device was carried on a ball and socket joint mounted on a perspex stalk fixed to the lens (Pritchard, 1961). The image was seen as at infinity and therefore was in focus for the normal relaxed eye. The target was illuminated by a small bulb behind a diffusing screen, and a shield protected the rest of the eye from stray light. The target was seen against a patch of light 5° in diameter and was within a central visual field of 2°. The lens fitted tightly enough to follow small eye movement accurately (Ratliff & Riggs, 1950; Riggs, Ratliff, & Armington, 1954). Tests on this system have shown slippage of lens and flexure of stalk to be negligible (Pritchard, 1958; 1961). Adjustments for aligning the position of the image were allowed by the ball-joint (see Figure 1).

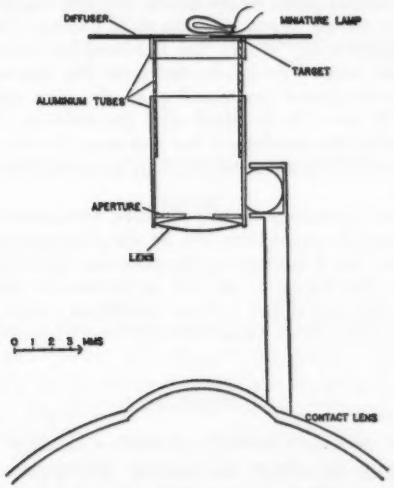

FIGURE 1. Contact lens and collimating system used to produce stabilized images (after Pritchard).

The tests were conducted in a quiet, lightproof room. Ss lay on their backs on a couch with their heads supported. They were given a sensitive (18 gm.) micro-switch and were instructed to press it each time the image disappeared, and to release it when the image was again visible.

Each time S pressed, a pen was deflected on a continuously recording kymograph which moved at the rate of one inch every 15 sec. The percentage of each 15-sec. interval that the image was visible was read directly in hundredths of an inch. Ss were two male university students whose vision was corrected to normal and who had had experience in wearing the contact lens.

The image presented in all conditions was a thin black line of 2′ arc width and 2° length on a white background. In the first experimental condition the left eye was covered so that no light could reach it. In the second, the left eye was covered with a half ping-pong ball, which provided a uniform diffuse white field whose light was approximately the same brightness as that of the stabilized field in the right eye. The third condition allowed patterned light to reach the uncovered left eye: S, being allowed normal vision in his left eye, was instructed to fixate a spot on the wall of a well-lit room. Fixation reduced the possibility of mechanical destabilization due to voluntary eye movements. Furniture and various pieces of laboratory equipment were visible, providing rich visual stimuli to the left eye.

There were four additional conditions with the left eye uncovered. An image identical to the one presented in the stabilized condition was projected simultaneously on a screen in front of S. The line on the screen was 2 mm. wide and was 8 ft. from S's eye. The resulting image had a 2′ arc width on the retina and was equal in length to the stabilized line. S looked at the screen with his left eye, while looking at an identical line stabilized in the right eye.

There were three fixation points on the screen. The first was 25 mm. to the right of the projected line, the second 75 mm., and the third 150 mm. (At this distance, 8 ft., 1 mm. is equal to approximately 1′ arc). The stabilized line in the right eye coincided with the fixation point; when S fixated the first point, the lines appeared parallel and close together. When he fixated the second point, the lines appeared further apart (75 mm. or about 75′ arc). In the third case, the stabilized line remained in the centre of the field while the unstabilized line was seen 150 mm. or about 2½° away, still parallel. There was a control condition with a curved line and a series of dots visible on the screen.

At least five separate recordings of each condition were made for each S. The duration of the testing period ranged from 5 to 30 min. for each condition. The first experiments showed that the frequency of disappearance of the figure was asymptotic at the end of 5 min. (See Figure 2) and did not increase or vary much with further continuous viewing. All comparisons between conditions and Ss were limited to the first 5 min. of the testing period. There was a 5-min. rest period between each trial.

Results

Of the first set of experimental conditions dealing with inter-ocular effects, the condition in which the subject had patterned, unstabilized, vision in the left eye gave most visibility and least frequent disappearance. The condition with the left eye covered (dark condition) gave the least visibility and most frequent disappearance. The mean visibilities obtained from subject A for the fifth minute were: 73, 58, and 30 per cent for the patterned, diffuse, and dark conditions respectively. Subject B gave 74, 51, and 37 per cent for the same order of conditions. The data obtained from subject A did not differ significantly from those of subject

B. The three conditions differed significantly at the .01 level (see figure 2).

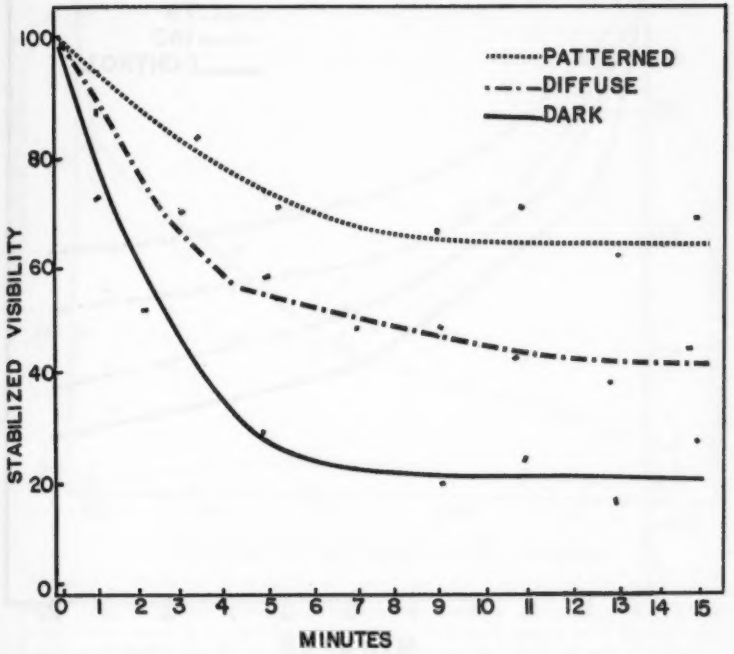

FIGURE 2. The visibility of the stabilized figure with patterned light, unpatterned light, and no light presented to contralateral eye (curve for subject A).

The second set of conditions presented the subject with two parallel vertical lines. Figure 3 shows the percentage of time the stabilized figure was visible for each of the three fixation points, as well as in the control condition when no parallel lines were visible. The data presented are again from subject A: they are not significantly different from those of subject B. As the apparent distance between the lines increased, the visibility of the stabilized image decreased. Subject A's mean recorded visibilities for the three distances during the fifth minute were: 62 per cent for 25 min. arc, 50 per cent for 75 min. arc, 44 per cent for 150 min. arc, and 42 per cent for the control condition. Subject B gave 56 per cent for 25 min. arc, 48 per cent for 75 min. arc, 36 per cent for 150 min. arc, and 33 per cent for the control condition.

An analysis of variance of trend (Edwards, 1954) for both subjects

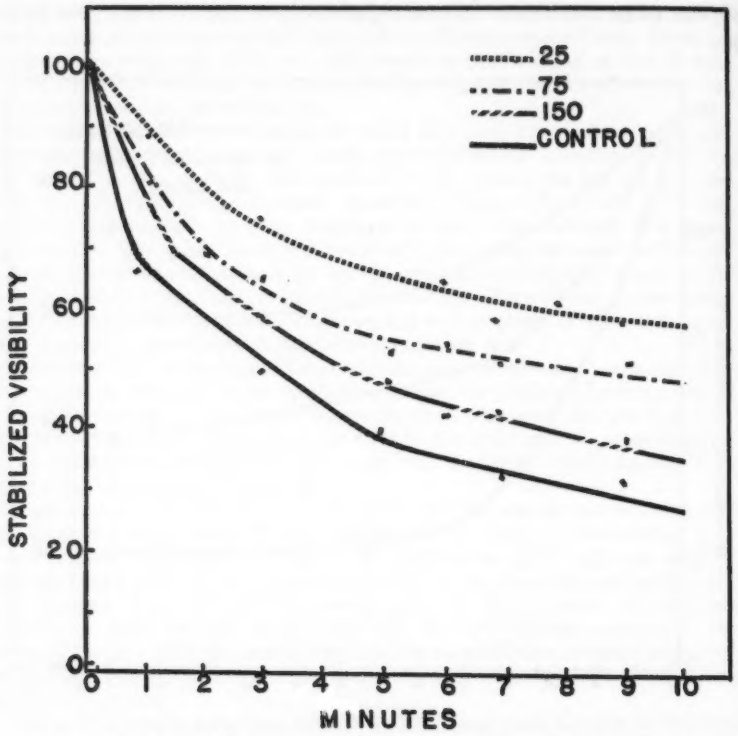

FIGURE 3. The visibility of the stabilized line with second line presented parallel but unstabilized to the contralateral eye at three distances. "Control" is the visibility of the same stabilized line with pattern of dots and curved line presented unstabilized (curve for subject A).

indicated that the visibilities for the three distances were significantly different at better than the .01 level, over the 5-min. viewing period (see Table 1). Figure 4 shows the mean visibilities for the fifth minute plotted

TABLE I

TREND ANALYSIS OF VARIANCE FOR TESTING PERIOD

	ss	df	ms	F
Conditions	1,448.2	3	482.7	23.3**
Error (between *Ss*)	457.5	22	20.7	—
Intervals	2,097.9	19	110.4	11.04**
Int. × Conditions	1,511.3	57	26.5	2.65**
Error (within cells)	5,639.5	418	10.0	—
TOTAL	11,154.4	519	—	—

**$p < .01$

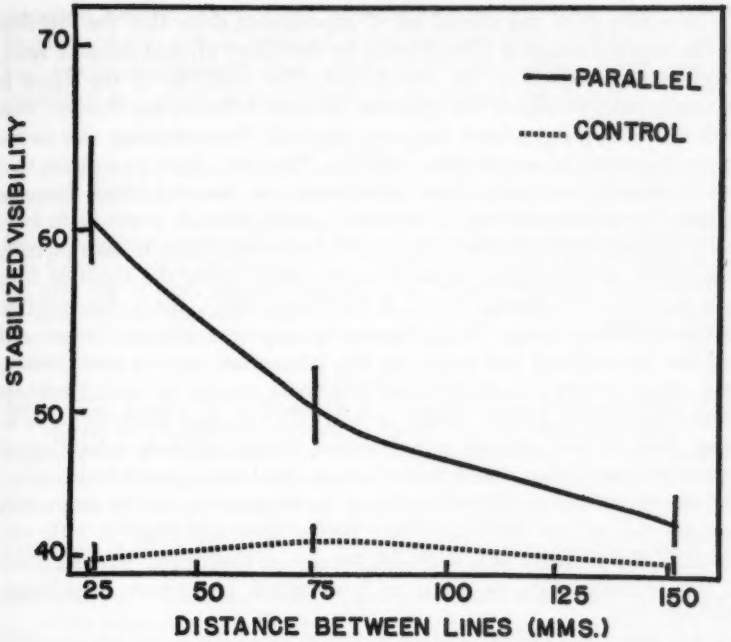

FIGURE 4. Decrease in visibility of stabilized line with increase in apparent distance from unstabilized line. Control shows visibility at corresponding fixation points when there is no parallel line present. At 8 ft., 1 mm. equals approximately 1 min. arc. Points represent means for the fifth minute (subject A).

against the apparent distance between the lines (Subject A). (1 mm. equals approximately 1 min. arc at 8 ft.)

The subjects occasionally reported that the fixation points seemed to disappear even though they were not stabilized. This may have been due to prolonged fixation. There were also a few reports that the stabilized line seemed to bend when it was seen near a bent or curved line.

DISCUSSION

The results from the first set of experimental conditions indicate that patterned light on the corresponding part of one retina maintains visibility of the stopped image on the contralateral retina better than unpatterned light, or no light at all. This is consistent with the idea that the fading of the stabilized image is influenced by central factors; an over-all increase in activity in one eye will facilitate vision of the stabilized image in the other.

The results from the second set of experiments show that the visibility of the stopped image is also affected by the shape of, and distance from, neighbouring objects in the visual field. The visibility of the figure is inversely proportional to the apparent distance between the images. That both stimulus images have the same physical characteristics also seems to be important in maintaining visibility. The data allow us to infer that neural activity resulting from presentation of the stabilized figure is affected by nearby activity of a similar nature, in such a way as to keep the stabilized object visible. This facilitation would have to take place in those parts of the central nervous system onto which the input of both eyes is projected (Burns, Heron, & Grafstein, 1960). Since the visibility of the stabilized image diminishes as the apparent distance between it and the unstabilized one increases, the interaction may be considered a field effect, perhaps resulting from reciprocal overlap of neural connections (Marshall & Talbot, 1942). A field effect is most likely to occur in those parts of the afferent visual system which maintain a topological representation of the visual field—that is, the lateral geniculate nucleus and the visual cortex. The retinae may be excluded as loci of interaction because the stimuli were presented binocularly, and there is little evidence of the presence of a sufficient number of centrifugal efferent fibres in the human retina to serve as intra-retinal facilitatory connections (Polyak, 1957).

Each line presented is assumed to generate a corresponding neural excitation in areas of topological representation. The neural excitation corresponding to the stabilized line is weaker than that of the unstabilized line due to the lack of varied stimulation allowed by the normal flick and drift movements of the eye. The unstabilized stimulus, being subject to normal eye movements, differentially excites the retina and does not allow adaptation and fatigue; thus a greater number of cortical cells will be excited compared to those excited by the stabilized figure. The closer the lines appear together the more overlap there is between their cortical fields, and the longer the stabilized image remains visible. This indicates that the excitation produced by the stabilized object is facilitated by the excitation caused by the unstabilized figure. When the lines are at the maximum separation, 2½° apart, the fields of neural excitation overlap very little (Clark, 1941). It should be noted, however, that the visibility of the stabilized line is still somewhat more than in the control condition in which the unstabilized stimulus was a curved line and a pattern of dots. Thus it seems that the similarity of the two stimuli is also a factor in producing greater visibility.

Pritchard, Heron, and Hebb (1960) found that, within a single stabilized image, elementary parts such as single lines tended to disappear and reappear as units. Furthermore, they found that "meaningful" figures

remained visible longer than "meaningless" ones. While these authors emphasized the role of meaning in maintaining the visibility of a stabilized image, the present study shows that field-distance effects are also important and must be considered in an explanatory theory.

Summary

Two subjects viewed a stabilized image of a straight line monocularly while various types of visual stimulation were presented to the other eye. In Experiment I these were: 1) darkness, 2) diffuse light, 3) patterned light. Patterned light was most effective in maintaining the visibility of the stabilized image and darkness least effective.

In Experiment II a line parallel to the stabilized line was presented unstabilized to the other eye at three apparent distances from the stabilized line. The visibility of the stabilized line increased when the two lines appeared closer together, indicating a field interaction. The results are explained in terms of neural interaction in the visual cortex.

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(First received March 8, 1961)

THE ROLE OF POST-EXPOSURAL EYE MOVEMENTS IN TACHISTOSCOPIC PERCEPTION[1]

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A NUMBER OF RECENT EXPERIMENTS (for example Mishkin & Forgays, 1952) have demonstrated that some stimulus objects are more easily recognized when exposed in one part of the visual field than when shown in another area of equal acuity. The relative probability of recognition has been shown to depend on such variables as the reading experience of the subject (Forgays, 1953; Orbach, 1952), the location of the stimulus objects relative to the fixation point (Heron, 1957; Kimura, 1959; Mishkin & Forgays, 1952), and the type of material used (Heron, 1957; Terrace, 1959).

Heron (1957) has suggested a possible mechanism, involving feedback from post-exposural eye movements, to account for the phenomena observed in tachistoscopic recognition experiments of this sort. He postulates that eye movement tendencies, developed while learning to read, produce differential feedback effects depending upon the type and location of the stimulus material.

The purpose of the present investigation was to study the relation between the recognition of tachistoscopically exposed material and eye movements occurring after the exposure of the material. A preliminary experiment, using a corneal reflection technique for measuring eye movements, lent some support to the idea that eye movements and recognition scores were related. Nineteen of twenty-nine subjects ($p = .14$) showed a positive relation between post-exposural eye movements and locus of recognition: they tended to look towards the place where the material they identified correctly had appeared. There was little relation, however, between eye movements and the order in which the subjects reported the material. Twelve of them always reported the material in a left-to-right order, eleven made more reversals of order with left eye movements, and six made more reversals with right eye movements ($p = .33$). Although inconclusive, these results seemed to warrant further experimentation.

In the preliminary experiment, the sensitivity of the corneal reflection method was relatively low, and many of the subjects made few move-

[1]This paper is based on parts of a Ph.D. dissertation submitted to McGill University, August 1961. The study was supported by the Defence Research Board (Grant 9401-11). The author is indebted to Dr. Woodburn Heron for his advice and assistance, and to Dr. Roy M. Pritchard for the construction of the eye movement recording apparatus.

ments which could be scored. Thus there was only a limited amount of data available, and rather crude statistical tests had to be used. In order to investigate the problem more fully, therefore, a more sensitive eye movement measuring technique was adopted, similar to that described by Ditchburn and Ginsborg (1953).

Method

S was fitted with a special tight contact lens for his right eye. A lucite stalk extended from this lens, and a small plane mirror was affixed to the stalk. Light was then reflected from the mirror to a moving film, and horizontal eye movements recorded in this manner. The apparatus proved to be highly sensitive, and small eye movements of the order of 3 min. arc could be reliably recorded.

In order to eliminate head movements as much as possible, S's head was held in place by an individually-fitted mouthpiece of dental wax. The stimulus material was projected onto a white screen 78 in. from S's eye, by means of a Keystone overhead projector fitted with an Ilex shutter set for an exposure time of 40 msec.

Two types of stimulus material were used: one type consisted of a row of six capital letters, the other of a row of six familiar geometrical forms (heart, star, triangle, etc.). When projected, the row was centred at a small fixation point marked on the screen, and subtended a total angle of 9 degree 18′ on each side of the fixation point. The stimulus objects were 1° 41′ high and 1° 28′ wide. Each object appeared equally often in each of the six positions. There were 16 examples of each type of material.

S was told to maintain fixation after the ready signal until the stimulus material had been exposed, and not to move his head until instructed to report the objects he had seen. The period between the ready signal and exposure was 2 sec., and that between exposure time and report about 3 sec.

Because each S had to be fitted with a special contact lens, only five were used in this experiment. Two Ss were shown the letter slides first, and three were shown the forms first. Before testing, S was familiarized with the geometrical forms, but no practice trials were given with either type of material. Ss were told which type of material would be presented.

Two different types of eye movements appeared on the records. Most of them were rapid movements to one side or the other, taking about 0.1 sec. to execute. In some cases the eyes returned immediately to the original fixation point after such movements. The remaining movements were gradual drifts at a rate of 12-30 min. arc/sec. For a movement to be scored, a movement of at least 3 min. arc without a return, a discrepancy of at least 6 min. arc between a movement and a return, or a steady drift of 6 min. arc or more had to be found. These values represent the smallest changes which could be reliably measured from the record.

The largest post-exposural eye movement, the measure found to be most closely related to recognition in the preceding experiment, was used as the measure of eye movement. This movement was classified as to type (rapid or drift), direction, and magnitude. In the final analysis, however, only the direction of the movement was considered, since the preliminary analysis showed that there was no basis for assuming that one type of eye movement was more related to recognition than another. Magnitude was not considered in the final analysis since there was no way of determining whether a drift and a flick of the same magnitude were equivalent, and since many movements were large enough to go off the record.

For each trial, a mean locus of recognition was found by arbitrarily assigning the value 1 to the object farthest to the left, and numbering the positions sequentially to 6, the position farthest to the right. The mean locus for the trial was taken as the mean of the values for the correctly recognized objects. For example, if *S* reported the objects in positions 1, 3, 4, and 5, his mean locus of recognition for that trial was 13/4 or 3.25.

Results

Table I shows the mean locus of recognition as a function of type of material and direction of eye movement. A product-moment correlation between direction of eye movement and mean locus of recognition was

TABLE I

Mean Locus of Recognition Scores for Alphabetical and Geometrical Material

Material	Subject	Accuracy (per cent)	Mean locus of recognition[1]				
			All trials	σ	Left move	No move	Right move
Letters	A	82	3.63	0.29	3.48 (8)	———	3.70 (7)
	B	66	3.21	0.31	3.17 (3)	3.05 (7)	3.41 (6)
	C	51	3.52	0.64	3.22 (9)	3.90 (7)	———
	D	56	2.34	0.52	2.02 (8)	2.73 (3)	2.63 (5)
	E	64	3.33	0.47	3.21 (13)	3.38 (2)	3.50 (1)
Forms	A	39	3.70	0.94	3.55 (9)	5.00 (1)	3.70 (5)
	B	55	3.24	0.71	3.00 (2)	2.61 (3)	3.45 (11)
	C	43	3.37	0.61	3.38 (7)	3.07 (7)	4.33 (2)
	D	46	2.37	0.67	2.29 (8)	2.31 (6)	2.91 (2)
	E	35	3.23	0.74	2.94 (9)	———	3.60 (7)

[1]Numbers in parentheses indicate the number of trials on which a particular type of eye movement was made.

computed for each subject for both alphabetical and geometrical material. These correlations are shown in Table II. With letter material, 3 of the 5 correlations reach the .05 level of significance, and all are in the same direction. Although the range of correlations is quite large, they do not differ significantly from one another, and an average correlation, using

TABLE II

Correlations Between Direction of Eye Movement and Locus of Recognition

Subject	Letter material			Geometrical material		
	N	*r*	*p*	*N*	*r*	*p*
A	15	.548	.04	15	.102	.73
B	16	.382	.14	16	.368	.15
C	16	.545	.03	16	.282	.30
D	16	.568	.03	16	.242	.37
E	16	.108	.70	16	.468	.07
WEIGHTED AVERAGE	64*df*	.445	.01	64*df*	.307	.02

weighted z-scores, was determined. This average correlation is +.44 ($p < .01$). With geometrical material, all of the subjects show a positive correlation, but none reaches the .05 level. Again the correlations do not differ from one another, and the average value is +.31 ($p < .02$).

Four of the five subjects show a higher correlation for the letter material than for geometrical material. Although this difference is not statistically significant, it does suggest that post-exposural eye movements are more important for the recognition of letters than for forms. There is also, however, a tendency for subjects who have a high correlation for one type of material to show a low correlation for the other (rho = −.90).

On more than half the trials, subjects reported the material in a consistent left-to-right order. Table III gives the proportion of trials on which

TABLE III

THE RELATION BETWEEN DIRECTION OF EYE MOVEMENT AND ORDER OF REPORT

	Trials showing reversals in order of report (per cent)							
	Letter Material				Geometrical Material			
Subject	All trials	Left move	No move	Right move	All trials	Left move	No move	Right move
A	60	63	—	57	33	11	0	80
B	25	33	29	17	63	0	67	73
C	38	44	29	—	63	75	50	50
D	13	0	33	20	44	38	50	50
E	44	47	0	100	19	22	—	14
MEAN	36	37	24	49	44	29	42	53

one or more reversals of this left-to-right order occurred. There are no significant associations between reversals in order and eye movements in a particular direction, although there is a slight tendency for more reversals to occur with right eye movements, especially with the geometrical material. In addition, there is a rank-order correlation of +.90 between the number of reversals and mean locus of recognition for alphabetical material: Subjects who make many reversals in order also tend to recognize material further to the right than those who make few reversals. The corresponding correlation for geometrical material is +.18. These results are in general agreement with Bryden's (1960) finding that order of report is an important factor in tachistoscopic recognition.

DISCUSSION

A correlational analysis was used because individual differences in eye movement tendencies did not seem to be related to differences in over-all

mean locus of recognition: subjects who tended to recognize material on the left side were not necessarily those who made the most left eye movements. This suggests that post-exposural eye movement tendencies are not a major factor in determining individual differences in tachistoscopic recognition. Such differences seem to be much more closely related to order of report tendencies and to differences in over-all accuracy. Furthermore, there does not seem to be much evidence to support Heron's (1957) notion that post-exposural eye movements are involved in determining the order of report.

Once individual differences have been discarded, the results suggest that post-exposural eye movements have some facilitatory effect. An eye movement to one side may serve to facilitate traces of objects which have recently appeared on that side, thus making it more likely that those objects will be identified correctly. The idea that eye movements have such a facilitating effect is consistent with the theory of perceptual learning advanced by Hebb (1949). This mechanism provides a means for accounting for some of the trial-to-trial variation within subjects, and may be of considerable importance in immediate memory. Motor feedback, such as that from post-exposural eye movements, may serve to facilitate specific traces and thus keep them from fading below the threshold necessary to produce a response.

It should be noted, however, that the results of this experiment do not demonstrate a causal relation between eye movements and recognition. While there appears to be some justification for making this assumption, it is quite possible that eye movements are a result of recognition rather than serving to facilitate it. The resolution of this problem requires studies of the development of the relation in children or investigations in which eye movements are manipulated experimentally.

Summary

An experiment was designed to investigate the relation between the recognition of tachistoscopically presented material and the direction of post-exposural eye movements. A significant relation between eye movements and locus of recognition was found for both alphabetical and geometrical material. No relation was observed between eye movements and order of report. The results suggest that post-exposural eye movements serve to facilitate recognition of tachistoscopically exposed material.

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CORRECTION

The following corrections should be made to the article by E. James Archer, *et al.* on Serial-Trigram Learning which was published in the September, 1961, issue of the *Journal*:

Page 148, line 19, "three" instead of "four."

Page 151, line 7, "four" instead of "two."

THE SQUIRREL AS AN EXPERIMENTAL ANIMAL: SOME TESTS OF VISUAL CAPACITY[1]

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SEVERAL FACTS SUGGEST that the squirrel should be a good experimental subject, especially for studies on vision. The natural habitat and general behaviour of diurnal tree squirrels, such as the red squirrel *Scirius hudsonicus* and the grey *Scirius carolinensis*, indicate that vision must be excellent and that dexterity and activity are good. Detailed study of the retina of the red squirrel supports the first point (Polyak, 1957) although no direct behavioural tests appear to have been made. One probable reason why squirrels have not been favoured with more attention as experimental animals is the fact that they are difficult to tame if caught after reaching maturity, and they can give an uncommonly fierce and painful bite.

The rat has been used extensively in the study of vision, yet it is not really a very suitable subject for this sort of work. It is primarily a nocturnal animal, visual acuity is poor, optic fibres are highly decussated and in general it does not appear to be an animal that relies much on vision. The poorness of detail vision in the rat is borne out by behavioural studies. Except in rather simple cases, learning tends to be slow and discrimination is often not very reliable. Because of this the payoff, in terms of experimental results, tends to be low, lengthy training procedures are required, performance is often erratic, and results may be difficult to interpret. (Cf., for instance, Dodwell 1960, 1961a). The squirrel, on the other hand, has an excellent peripheral visual system and tends to be active and "curious." Anthony (1928), for instance, specifically mentions its alert and "inquisitive" character. These factors suggested to the authors that it would be worthwhile to investigate the characteristics of the squirrel as an experimental animal, and in particular to study some of its abilities in visual discrimination. To this end, six Florida Cat squirrels were obtained from a commercial zoo, and a number of the local greys, *Scirius carolinensis leucotis*, trapped. Their general behaviour in the laboratory has been observed now for a period of about nine months, and some tests of visual discrimination performed.

TRAPPING, MAINTENANCE, AND GENERAL BEHAVIOUR

Local wild squirrels can be trapped quite easily. Originally we used a trap constructed out of a pair of standard rat cages, with an electrical

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trip mechanism and a magnetic lock on the door. However, squirrels are surprisingly strong and dexterous, and many managed to escape: subsequently we used a standard commercial trap for small animals, 14 × 5 × 5 in. in size, with a mechanical trip and locking mechanism. In both cases peanut butter was used as a lure, and proved to be very effective. The trapped animals were housed in wire cages 30 in. high, 24 in. wide, and 16 in. deep in a laboratory maintained at 70°F. These cages, a type designed for small birds, appear to be large enough for a pair of squirrels, but initially we had some difficulty in keeping them in, since the squirrels managed to bend and break some of the bars. The tendency to escape can be reduced by providing nesting boxes. We use nesting boxes made of galvanized metal, dimensions 9 × 9 × 9 in., attached to the outside of the cages: since installing them there have been no escapes nor, as far as can be determined, any attempts to do so. The squirrels tend to remain in the boxes a great deal, even under conditions of daylight and high temperature.

There is a typical response to captivity; at first the squirrels are very active and aggressive, will chatter and growl when anyone enters the room, and attempt to bite on the slightest provocation. After about two days they become lethargic and "sullen," and one suspects some sort of disease. Typically this lasts for less than a week, and then they become active again, but are less aggressive than before. They will "freeze" when the cage is opened, but do not attempt to bite unless one actually tries to catch them in the hand.

Attempts were made to tame both the Florida and the local squirrels, by handling them daily with thick leather gloves. After four weeks, and a number of painful bites, this was discontinued, since there was no apparent improvement in behaviour. Even after three months' experimental work the squirrels still responded to handling by biting, so it seems unlikely that squirrels caught at maturity can be tamed sufficiently to be handled as rats are. We therefore devised an experimental procedure which involved no direct handling, which proved to be satisfactory (see below). Anecdotal evidence indicates that squirrels can be tamed sufficiently to be handled, but this may be true only of squirrels caught when quite young.

Of more practical interest is the question whether squirrels can be bred in captivity. It is hoped that, should this prove possible, animals bred in captivity would be easier to tame than others, thus leading to simplification of experimental procedures. Marmosets can be bred in captivity when irradiated with ultraviolet light (Lucas, Hume, & Smith, 1927, 1937) and we found that squirrels so irradiated show secondary sexual developments, such as fur changes and increase in size of testes in the males. Copulation also occurs, but so far there have been no

fertile matings. Studies on the ferret (Bissonette, 1932, 1935) show that increased photo-period is sufficient to bring on œstrus in the female and cause secondary sexual changes in the male, but with incomplete spermatogenesis. In these and related studies temperature was not considered as a possible variable: it seems possible that a decrease in temperature might be required to obtain complete spermatogenesis in the squirrel. In ground squirrels (Wells, 1935) and rams (Hafez, 1951) decrease in temperature below 40°F is a necessary condition for complete spermatogenesis. Investigations of light and temperature changes on the sexual characteristics and behaviour of the squirrel are being made, with the hope that sufficient conditions for obtaining fertile matings in captivity can be established.

Squirrels are very hardy in captivity. There have been no diseases, and with one exception the only fatalities occurred amongst animals anaesthetized with chloroform in the first attempts to remove them from the trap. In this case the fatality rate was high (seven out of eight), although death occurred in some cases as much as eight days later, the squirrels appearing in the meantime to be quite normal. Our squirrels are fed on a mixture of sunflower seed, corn, peanuts, and raisins, in the ratio of 4:4:2:1, and eat only about 2 oz. each per day. They drink water from the same type of bottle as rats. They are thus quite cheap to maintain, as well as being hardier, cleaner, and less malodorous than rats.

The Visual System of the Squirrel

Relatively few details of the neuroanatomy of the squirrel have been studied. A recent major treatise on vertebrate neuroanatomy (Kappers, Huber, & Crosby, 1960) has only two references to the squirrel; one to an obscure ramification of the spinal tract, the other to the number of taste buds. Polyak (1957) describes the retina and optic fibres, but far from exhaustively, and concludes that the squirrel's visual system undoubtedly represents the highest infra-primate level of development. It has predominantly cone vision (no rods have been positively identified) the "grain" being high and moderately uniform. Over a circular area of 500 microns in diameter in the lateral posterior region there are at least 10,000 cones, nearly one-third of the total number of cones in the human fovea, which has the same areal extent. The foveal floor of the rhesus macaque, measuring approximately 300 microns across, contains about 17,000 cones. The total number of cones is estimated at three million for the red squirrel, the number of optic fibres at about 200,000, compared with figures of six and one-half million and one million for humans. These facts indicate that squirrels should have good detail vision, although the ratio of cones to fibres is only 15:1.

The topography of the optic tracts has not been studied in detail. Most rodents have a large amount of decussation, but the squirrel may be an exception since it appears to have good stereoscopic vision. Unfortunately there is no direct evidence on the extent of decussation, and the supposition that stereopsis is fairly complete seems to be made by Polyak on commonsense grounds.

A comparison of the brains of rat and squirrel shows that there are no great differences in gross characteristics, although here again precise comparative data are lacking. It would seem safe to assume, however, that the major differences in visual capacity between these two species of rodent can be attributed to the great differences in peripheral visual equipment, rather than to differential development of the cerebral cortex.

A Preliminary Study of Detail Vision

Since normal handling proved to be impractical with our squirrels, some other procedure had to be devised. A wooden catching box was made, 9 × 4 × 3 in., with one large face open. This was used to trap a squirrel against the side of its home cage, and a piece of light sheet metal was inserted between the box and the cage. The squirrel was then transferred to a carrying box, described below, which was an integral part of the experimental apparatus. At the end of an experimental session the squirrel was transferred directly from a carrying box to the home cage. Catching was quite easy, and indeed several squirrels learned to transfer from the cage to the carrying box without having to be caught.

Apparatus

Since arboreal squirrels jump a great deal in their natural habitat, it was considered likely that a modification of the Lashley jumping stand would be suitable for studying their vision. A plan view of the stand used is shown in Fig. 1. A_1, A_2, and A_3 are three identical plywood carrying boxes, 9 × 9 × 9 in., with a removable sliding plexiglass door at **a**, and a removable sliding plywood door at the opposite end. B_1 and B_2 are stimulus cards, 18 in. square and painted matt black, set at 135° to each other, each with a closely fitting door, 6 in. square, set in its centre. Stimulus shapes could be attached to these doors (the shapes used are described below). D is a narrow jumping platform 1½ in. × 9 in. The area in front of the stimulus cards is totally enclosed, with plywood at the sides and top, plexiglass at the front and a shallow metal tray filled with about ¼ in. of water at the bottom. The jumping distance DC is about two ft. The carrying boxes are supported by platforms attached to the stand (E).

Procedure

Stimulus shapes are attached to the doors C, and the door with the negative shape on it locked. A carrying box, with plywood door removed, is placed behind the open door. Box A_1, containing a squirrel, is placed in position and, as the plywood door is slid aside, a closely-fitting plexiglass barrier is inserted into the box. The plexiglass door at **a** is then removed, and the barrier moved into the box to force the squirrel on to the jumping platform D through an aperture, 9 in. square,

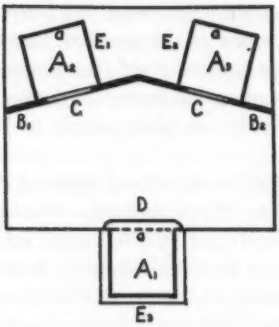

FIGURE 1. The jumping stand. A: carrying boxes. B: stimulus cards. C: doors. D: jumping platform. E: supports for carrying boxes.

in the plexiglass screen on the front of the stand. From the platform the squirrel jumps to one of the doors, C; if it makes a correct choice it arrives in the carrying box behind the stimulus card, the plywood door is reinserted, and the squirrel is ready to be transferred (in the carrying box) to the position A_1 for a further trial. If the squirrel chooses incorrectly it falls into the tray of water.

All the squirrels learned very quickly to jump from the platform to one of the doors: on the first two trials a narrow strip of plywood was placed from the platform to one of the doors (both doors being closed but not locked) and the squirrel encouraged to move by being blown on. No squirrel took more than two trials to learn to jump to the doors. They also learned quite quickly to jump from the water tray back on to the jumping platform, again being encouraged with a puff of air or by tapping on the metal tray. With this procedure it was found convenient to run two squirrels concurrently, trials being given alternately to the two. One remained in the unused carrying box whilst the other was on the stand. A small amount of peanut butter was placed in the "goal" box (the one behind the door with the positive shape on it) when a correct jump had been completed, but it turned out that the squirrels would jump readily without this reward, and frequently they did not eat between trials.

On completion of a day's trials, if a squirrel had been in the water it was placed in a drying unit for about 50 minutes. This consists of a small variable-speed fan which blows air over a pair of 660W tubular elements into a rectangular box, 12 × 10 × 5 in., divided into two separate compartments, each with its own sliding door, so that two squirrels could be dried at a time. (The same unit has been used successfully with rats). No ill effects such as respiratory diseases were encountered, and the squirrels always appeared to be in good shape after the drying treatment.

Subjects

Six squirrels were used, four Florida Cat squirrels and two of the melanic (black) form of the local subspecies. One of the latter died during the experiment: the cause of death was unknown. Autopsy showed that there had been a cerebral haemorrhage,

possibly due to impact with part of the jumping stand, since the squirrels tended to jump with surprising force.

Results

All squirrels were given, initially, a black-white discrimination, the white stimulus being a 3-in. square, and all showed immediate preference for this. In fact there were no jumps to the black door in ten trials for each squirrel. Following this the discrimination of horizontal from vertical striations was given, half the animals having horizontal, the other half vertical striations positive. All showed immediate and pronounced preference for the horizontals. Of the three trained to horizontals positive, one made no errors, one made two, and one three, in three days' training, ten trials per day. Of the other three only one achieved ten consecutive jumps to the verticals, after five days' training: on the first two days it jumped each time to the horizontals, then switched quite rapidly (on the next three days its numbers of correct jumps were six, nine, and ten). The other two became disturbed, refused to jump, or jumped wildly, so they were switched to jumping to horizontal positive, and quickly achieved perfect scores. The one that learned to jump to the vertical striations was a local squirrel.

The four Florida squirrels were then given training on the discrimination of equilateral triangles, one with base horizontal, the other inverted. These figures were outlined in white ink on matt black cards. The criterion of success was 20 consecutive jumps to the positive shape or 27 out of 30 correct. Of the four animals, two showed some initial preference for the triangle with base horizontal, one for the inverted triangle. These results are summarized in Table I.

TABLE I

Training on Equilateral Triangles (Positive, △; Negative, ▽)

S	Jumps to criterion	Errors	Initial preference
1	50	14	▽
2	60	11	△
3	70	17	△
4	70	25	None

After this, a series of transfer tests was given, with both doors unlocked. Each transfer test consisted of ten jumps. These are summarized in Table II. In the first test solid triangles were used, congruent with, and in the same orientations as, the training triangles. Transfer was high, but not perfect. The probability of obtaining the observed score or better

TABLE II

TRANSFER TESTS

	1	2	3	4	5	6	7	8	9	10
S	▲▼	△ ▽	△□	△◇	△○	△⬡	△⬠	△□	□○	◇○
1	7 3	10 0	6 4	9 1	10 0	8 2	10 0	2 8	10 0	4 6
2	8 2	8 2	8 2	9 1	10 0	10 0	10 0	2 8	8 2	0 10
3	8 2	7 3	5 5	10 0	8 2	9 1	10 0	2 8	10 0	3 7
4	8 2	8 2	5 5	9 1	9 1	19 0	9 1	6 4	10 0	2 8
χ^2	$p<0.01$	$p<0.001$	$p>0.10$	$p<0.001$	$p<0.001$	$p<0.001$	$p<0.001$	$p<0.025$	$p<0.001$	$p<0.005$

for each set of ten jumps was calculated separately, from the binomial expansion, with $p = q = \frac{1}{2}$. These probabilities were combined by a method suggested by Quenouille (1950, pp. 96, 97). The resulting $\chi_{(8)}{}^2$ was 20.2 ($p < 0.01$), showing that the number of jumps to the upright triangle was greater than could reasonably be expected by chance. The second test again used open triangles, but with small variations in size (both within and between pairs of presentations). This evidently did not upset the amount of transfer (Table II, col. 2). The next two columns show that while there is little, if any, preference for the original triangle over a square of the same area, there is marked preference for the triangle over the same square rotated through 45°. The next three columns show that the triangle is also preferred to a circle, hexagon, or pentagon of equal area. At this stage it looked as if the squirrels had simply learned to identify the triangle and neglect the other shape. To test this, the square was again shown with the triangle, the expectation being that the triangle would now be preferred (on the first test of triangle and square—the first test using a novel shape—very little tendency to prefer the triangle was observed). The result was surprising, and entirely baffling: the square was now preferred to the triangle by three animals at a high level of significance. Column 7 shows that the square was also preferred to a circle (Col. 9), but when the square was rotated through 45° the circle was preferred (Col. 10). This result also was baffling, and quite unexpected. The transfer series was terminated at this point.

The four squirrels were next retrained on the two original discriminations, both of which had been retained almost perfectly by three of them (retraining to a criterion of ten consecutive jumps to the positive shape was accomplished with a total of eight errors for all animals and both pairs of shapes). The fourth squirrel, during this retraining, became disturbed, refused to jump or jumped wildly, so was discarded from the remainder of the experimental programme. The next part of the programme involved superposition of pairs of previously learned shapes. First, the positive triangle was superimposed on the horizontal striations,

TABLE III

SUPERIMPOSED SHAPES

S	△ on horizontal striations	▽ on vertical striations	△ on vertical striations	▽ on horizontal striations
1	10	0	7	3
2	9	1	7	3
3	9	1	3	7
χ^2	$p < 0.001$		$p > 0.05$	

the negative one on the verticals (that is, positive on positive, negative on negative). Discrimination between the pair was almost perfect (Table III, col. 1). When the superpositions were reversed, however, the results were less clear-cut: two squirrels appeared to show a preference for the positive triangle, and one for the horizontal striations; but the results are not significant. This is markedly different from the result of Lashley's similar experiment with rats (Lashley, 1938).

While the Florida squirrels were undergoing the above-described sequence of tests, the one remaining local squirrel (the only one to learn to jump to the vertical striations) was tested, first, for transfer to single vertical and horizontal lines. Transfer was not complete, and the squirrel was trained to discriminate between the pair. This required three days, with ten trials per day as before, the numbers of errors being three, two, and zero on these days. It was then tested for angular discrimination by rotating the horizontal towards the vertical. On successive days the angles between the two lines, and the numbers of errors were: 60°, one error; 45°, two errors; 30°, two errors; 15°, six errors, and on a second day's testing, five errors. Thus, the discrimination of a 15° difference in orientation appears to be difficult for the squirrel, but may be attainable with further training.

A final subsidiary test was given to the four squirrels remaining, to discriminate between two pairs of shapes previously used to test predictions from two theories of shape discrimination (Dodwell, 1962). One of the theories was suggested by Sutherland (1957) and the other by the senior author (Dodwell, 1957). The shapes are shown in Figure 2. According to Sutherland's theory the pair a,b, should be easily discriminable but not the pair c,d. Dodwell's theory predicts the reverse. Two squirrels were trained on the first pair, two on the second. Each S was given 60 trials. The pair trained on the shapes a,b chose correctly 38 and 27 times; the other pair chose correctly 44 and 39 times. Using a normal approximation to the binomial expansion, with mean of 30 and standard deviation of 3.873, the probabilities for the numbers of correct jumps

FIGURE 2. Shapes used in the final discrimination test (see text).

(corrected for continuity) are: shapes a,b: $p = 0.026$ and $p = 0.348$; and shapes c,d: $p = 0.0002$ and $p = 0.014$. This is a one-tailed test for discrimination of the positive shapes. Combining the probabilities as before, $\chi^2_{(4)} = 9.396$, $p > .05$ for discrimination of a,b; $\chi^2_{(4)} = 26.2$ ($p < .001$) for c,d. For a two-tailed test the probability values should be doubled: in either case it is clear that the discrimination of c,d is easier than the discrimination of a,b. Lest it be thought that this method of analysis does not adequately reflect changes in discrimination behaviour over the learning period (for example, those learning shapes a,b might have shown significant discrimination on the last day) it may be added that on every day but one (the second) the numbers of correct jumps for the pair c,d exceeded the number for a,b; and on the last day correct jumps for c,d were ten and eight, for a,b they were six and five. Thus, the test lends some support to Dodwell's theory over Sutherland's.

DISCUSSION

It is clear from the foregoing descripitions that squirrels are excellent subjects for work on visual discrimination. The time required for teaching them to jump in the stand is negligible, and discriminations are formed rapidly, at least with simple geometrical shapes. Perhaps the most important findings of this investigation are, first of all, that squirrels show very strong natural preferences in some visual discriminations, which

appear to be rather consistent from one animal to another, and secondly that shapes must be classified by squirrels in some quite definite way. The classification system presumably determines "equivalence," or lack of it, between pairs of shapes, as demonstrated in the transfer tests. It could be argued that the transfer data of Table II are not transfer data at all, but simply reflect marked preferences for certain shapes over others, or that the transfer tests are situations in which very rapid learning occurs. This argument is not altogether plausible, since the final discrimination tests did not show immediate and consistent preference, and in some cases the amount of transfer was greater than in others (for example, Table II, cols. 7 and 8). The presently reported findings are merely a preliminary study, and it was thought more important to find out how consistent the results of the same tests would be for the whole group than to vary the tests, or order of tests, for different subjects. Obviously much more extensive investigations will be required to decide whether the data of Table II are to be interpreted as transfer data or not: they would have to include such things as varying the order of the transfer tests, using each pair separately as original training shapes, and investigating further the effects of changing the orientation of the shapes. The only data on the last point, so far, are contained in Table II, cols. 3 and 4, and cols. 9 and 10, which show that rotation of a square through 45° has a considerable effect on the way it is responded to.

Whatever the final interpretation, the results so far reported strongly reinforce an argument put forward elsewhere (Dodwell, 1961b) to the effect that more attention should be given to the ways in which stimuli are actually classified by different organisms before attempting to devise theories of discrimination learning. Several theories for shape classification have been put forward (Deutsch, 1955; Dodwell, 1957; Sutherland, 1957) but none of them can explain the present data. After more extensive investigation it is hoped that some definite hypotheses about the shape classifying system (or systems) of the squirrel can be elaborated.

Summary

The possible advantages of the squirrel as an experimental animal are considered. Methods of trapping squirrels and maintaining them in the laboratory are described.

Six squirrels, four Florida Cat squirrels and two melanic local greys (*Scirius carolinensis leucotis*) were used in preliminary tests of visual discrimination, using a modified Lashley-type jumping stand. Squirrels turned out to be eminently suitable subjects for this type of experiment. The results show that squirrels have some strong natural visual preferences, that discrimination between pairs of simple geometrical shapes can be achieved quite rapidly, and that shape classification is rather consistent from one squirrel to another. The significance of these findings for theories of shape discrimination is considered.

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PERIPHERAL SENSORY LOSS AND EXPLORATORY BEHAVIOUR[1]

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MANY PREVIOUS EXPERIMENTS (for example Hunt & Schlosberg, 1939; Browman, 1942) have investigated the effects of peripheral sensory loss on the general activity of the rat. However, effects of sensory loss on exploratory behaviour, that is, on changes in behaviour in response to novel situations, have so far received little attention. As Glickman (1958) has noted, his was the first study to be concerned with the effects of sensory loss (in that case, enucleation of eyes) on the exploratory behaviour of the rat.

The present study was undertaken to determine the effects of two types of peripheral sensory loss, enucleation of eyes and removal of vibrissae, on the exploratory behaviour of the rat. The effects of two other variables were also studied. First, an attempt was made to determine whether the age at which the sensory loss is sustained influences exploratory behaviour. Second, the effects of the interval elapsing between sensory loss and tests of exploratory behaviour were studied. Two components of locomotor behaviour, rearing and walking, were employed as measures of exploration; these were measured by a modified time-sample method.

METHOD

Subjects

Seventy-six experimentally naïve male hooded rats served as subjects in this study. Of these, 44 were obtained at the age of weaning (20 days); they ranged in weight from 30 to 45 gm. The remaining 32 rats were about 70 days old at the beginning of the experiment; they ranged in weight from 180 to 220 gm.

Living and Testing Cages

The living cages were constructed of metal, painted grey. Each measured 24 × 12 × 8 in. The floor of each cage was covered with sawdust. The animals were housed six to a cage. The test cage was 13 in. long, 10¾ in. wide, and 9¾ in. high. Apart from the difference in size, the test cage differed from the living cages in that its floor and roof were constructed of ¼ in. wire mesh. Food and water were available at all times except during the test sessions.

Procedure

On arrival at the laboratory, the animals were given two days to become accustomed to their living cages. On the third day, each subject was injected intraperitoneally with an anaesthetic dose of sodium pentabarbital; the animals were then

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divided into four groups, as follows (see Table I). The eyes of animals in the first group were enucleated (Group E). The animals in the second group were deprived of their vibrissae only (Group V). Both the eyes and vibrissae were removed in the case of the animals in the third group (Group EV). The fourth group served as a control (Group C). In the interval between division into groups and testing, the vibrissae of animals in V and EV groups were closely clipped on alternate days.

TABLE I

DESCRIPTION OF THE THREE EXPERIMENTAL CONDITIONS AND OF THE FOUR GROUPS

Condition	Approximate age at operation	Approximate age at testing	Groups
Young-Young (Y-Y) $N = 20$	23 days	35 days	E—eyes enucleated V—vibrissae removed EV—eyes enucleated and vibrissae removed C—control
Young-Mature (Y-M) $N = 24$	23 days	85 days	E—eyes enucleated V—vibrissae removed EV—eyes enucleated and vibrissae removed C—control
Mature-Mature (M-M) $N = 32$	70 days	90 days	E—eyes enucleated V—vibrissae removed EV—eyes enucleated and vibrissae removed C—control

The effects of age at the time of sensory loss and the interval between sensory loss and tests of exploratory behaviour were investigated by the following arrangement. Twenty weanlings were divided into the four groups (5 E, 4 V, 5 EV, and 6 C) at the age of 23 days and were tested at the age of 35 days. This is designated as the Young-Young (Y-Y) condition (Table I). Twenty-four other weanlings were divided into the four groups (6 E, 5 V, 3 EV, and 10 C) at 23 days of age and were tested at the age of 85 days. This is the Young-Mature (Y-M) condition. The thirty-two animals that were mature at the onset of the experiment were divided into the four groups (10 E, 6 V, 7 EV, and 9 C) and were tested at 90 days of age. This is referred to as the Mature-Mature (M-M) condition.

For testing, each animal was removed from its living cage and placed in the test cage. The only light in the room was provided by a 40-w. electric bulb placed 3½ in. above the wire-mesh roof of the cage. The animal was observed through a one-way screen placed in front of the cage. The behaviour of the rat was observed and recorded for 10 min.; then the animal was returned to its living cage. Each rat was given one such testing session on each of three consecutive days.

Response Categories

A modified time-sample method, described by Bindra and Blond (1958) was used for recording the various specific acts of the rat. The method consists of recording the particular act in which the animal is engaged at the beginning of each *x*-sec. interval. In the present experiment, the response at the beginning of each 6-sec. interval, indicated by the click of a timer, was recorded. Thus, in each test session a total of 100 entries for the 10-min. observation period was made for each rat. Each entry consisted of one of the following categories of response:

M–motionless: rat sits completely motionless or slightly trembling in hunched or prone position, with eyes open, for at least six seconds.
S–sitting.
G–grooming: rat licks, scratches, or "washes" any part of its body.
R–rearing: rat stands on hind legs.
W–walking.
These categories were found to be jointly exhaustive for all behaviour occurring in the test situation.

Results

The mean frequency of each response category was calculated for the different groups. However, only W (walking) and R (rearing) responses are considered here. For the most part, changes in the frequencies of M (motionless), G (grooming), and S (sitting) were the obverse of changes in W and R. Since this experiment was concerned with exploratory behaviour, the two locomotor components (R and W) only are considered. The means and ranges of the scores obtained by the groups under the different conditions are presented in Table II.

A two-way analysis of variance (3 age conditions × 4 sensory-loss

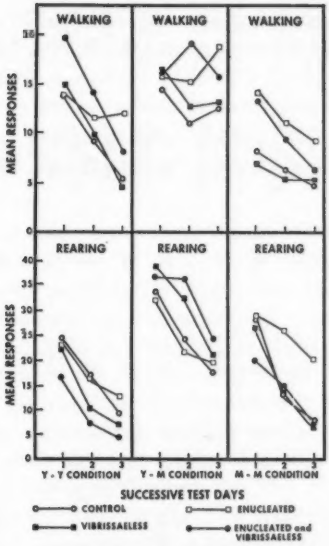

Figure 1. Mean frequency walking and rearing responses on successive test sessions made by the different groups in the three experimental conditions.

TABLE II

MEANS AND RANGES (IN PARENTHESES) OF THE FREQUENCY OF REARING AND WALKING RESPONSES MADE BY DIFFERENT GROUPS UNDER EACH OF THE THREE CONDITIONS

Condition	Group	Sample size	Rearing			Walking		
			Day 1	Day 2	Day 3	Day 1	Day 2	Day 3
Young–Mature	C	10	34.0 (15–51)	24.3 (14–32)	17.8 (6–28)	14.6 (8–23)	11.0 (4–15)	12.8 (4–22)
	V	5	39.4 (28–52)	32.8 (12–56)	20.8 (9–27)	16.4 (8–23)	12.8 (6–21)	13.0 (9–17)
	E	6	32.3 (13–49)	21.8 (14–33)	19.5 (5–28)	15.8 (12–21)	15.2 (7–30)	18.8 (14–26)
	EV	3	37.3 (33–46)	37.0 (23–50)	24.3 (17–34)	16.0 (14–18)	19.0 (16–25)	15.7 (11–24)
Young–Young	C	6	24.7 (11–46)	17.0 (9–26)	9.5 (3–19)	14.0 (11–16)	9.3 (5–13)	5.8 (2–14)
	V	4	22.3 (14–36)	10.3 (5–14)	7.0 (3–10)	15.0 (7–24)	9.8 (5–19)	4.8 (2–11)
	E	5	22.8 (11–41)	16.8 (9–24)	13.0 (2–29)	14.0 (5–21)	11.6 (2–20)	12.0 (7–16)
	EV	5	16.6 (4–28)	7.6 (2–19)	4.8 (0–12)	19.8 (9–28)	14.2 (3–22)	8.2 (3–20)
Mature–Mature	C	9	28.2 (19–40)	13.1 (1–26)	8.1 (0–25)	8.2 (3–15)	6.8 (1–22)	5.0 (3–9)
	V	6	26.8 (13–47)	13.8 (8–21)	7.2 (0–23)	7.3 (5–12)	5.7 (4–7)	5.2 (1–12)
	E	10	28.6 (13–44)	26.3 (3–50)	20.4 (4–48)	14.2 (8–20)	11.0 (5–19)	9.4 (4–18)
	EV	7	19.9 (12–32)	15.1 (8–23)	7.4 (3–16)	13.4 (7–18)	9.4 (5–16)	6.7 (3–10)

groups) was conducted separately for walking and rearing scores. The score for each animal was the mean of the frequencies for the three test days. Appropriate corrections (Ferguson, 1959, p. 259) for unequal numbers in the subgroups were made in these analyses. The significance of simple effects was determined by two-tailed *t*-tests; results reported as significant had *p* values of less than .05 or .01.

Walking

The analysis of variance showed that walking was affected significantly by both the age ($F = 45.94$; $p < .01$) and the sensory-loss ($F = 14.41$; $p < .01$) variables; the interaction effect was not significant. So far as the age effect is concerned, rats in the Y-M condition walked significantly more than those in the Y-Y condition, which in turn walked significantly more than those in the M-M condition; the same effect prevailed within each of the four groups, including the control group. However, a reference to Figure 1 will show that the higher walking scores of the Y-M animals arose mainly from the fact that they did not show the same decline in walking over the three test sessions as did the Y-Y and M-M animals.

Turn now to the effects of sensory loss. In the M-M condition both enucleated animals (Group E) and enucleated and vibrissaeless animals (Group EV) walked significantly more than the control animals (Group C), and the vibrissaeless animals (Group V). In the Y-M condition, the E and EV groups walked significantly more than the control group but not more than the V group. In the Y-Y condition, the EV group, but not the E Group, walked significantly more than the C and V groups.

Rearing

The analysis of variance for rearing showed that it was affected significantly by the age variable ($F = 23.41$; $p < .01$). The animals in the Y-M condition reared significantly more than the animals in both the Y-Y and the M-M conditions; however, no reliable difference existed between the Y-Y and M-M conditions. The difference between the Y-M and the other conditions was significant ($p < .05$ or better) within three of the four groups, not reaching significance only in the case of Group E.

The effect of the sensory-loss variable was not significant. However, the interaction between age and sensory loss was significant ($F = 2.50$; $p < .05$), probably owing to the fact that the direction of the effect of sensory loss was not the same in the Y-M condition as it was in the Y-Y and M-M conditions. Consequently, a further analysis of the sensory-loss effects seemed justified. This showed that, in the Y-Y condition, the vibrissaeless animals (Groups V plus EV) had a tendency to rear less ($p < .10$) than the corresponding animals in Groups E and C. In the M-M condition, the enucleated animals (Group E) reared significantly

more than the animals in the other groups. No sensory-loss effects in the Y-M condition were significant.

Discussion

Since rats are more active in the dark (see for example, Hunt & Schlosberg, 1939), one would expect that blind rats would be more active than sighted ones. Generally, this has been found to be the case (for example, Browman, 1942). However, in these studies the activity of the animals was measured in situations to which they were already well accustomed. Therefore, they do not provide a basis for predicting the locomotor behaviour of blinded rats in a novel situation. In fact, the degree of novelty, or change in stimulation from the living to the test cages, must be different for animals with varying degrees of sensory loss. That in the present investigation we were dealing with exploratory behaviour (in a new situation) rather than with general activity (in a familiar situation) is shown by the fact that the locomotor responses in the test situation decreased from day to day (see Figure 1) with increasing exposure to it, a pattern of change noted by most investigators of exploratory behaviour (for example, Berlyne, 1955).

The present results show that the animals operated upon when young and tested at maturity (the Y-M condition) reared and walked more than the animals in the other two conditions. Since this difference occurred even in the control group, where no sensory loss but only surgical anaesthesia was inflicted on the animals, it must be attributed to some factor operating during the interval between the administration of the anaesthetic and the tests. In the case of Y-Y and M-M conditions, this interval was 20 days or less; in the case of Y-M condition it was over 60 days. Whether the crucial factor operating was the residual effect of anaesthesia (Stern, 1960) or some other variable we are unable to say on the basis of the present data. Nor can we offer any explanation for the differences between the Y-M animals and the animals in the other two conditions in the pattern of walking scores over the three test sessions.

Broadly speaking, the effect of sensory loss seems to be to increase walking and rearing. In the animals that suffered sensory loss at maturity (M-M condition), blinding produced the main effect; enucleated animals, in general, walked and reared more than the control animals. However, in the young (Y-Y condition), the enucleation or the removal of vibrissae by itself did not increase walking; only in animals which were both blind and vibrissaeless were the walking scores greater than those of the control animals. Thus, in order to produce an increase in walking, a greater sensory loss seems to be required in the young animals than in the adult animals. Also, in determining exploratory behaviour, blinding seems to be more important in the adult animals than in the young. In

the Y-Y condition, the vibrissaeless animals (Groups V and EV) had a tendency to rear less than the control and enucleated animals. This trend, contrary to the above generalization, may be accounted for as follows: it is known (Small, 1899) that rearing responses emerge relatively late in the infancy of rats; by contrast, walking is well established by the normal time of weaning (20 days). Thus it is possible that the removal of vibrissae delayed the normal emergence of rearing responses in the animals in the Y-Y condition. However, the delayed onset of rearing is apparently only a temporary effect, for the vibrissaeless animals in the Y-M condition did not rear less than the other animals in that condition.

Summary and Conclusion

This study was concerned with the effects of two types of peripheral loss, enucleation of eyes and removal of vibrissae, on two components (walking and rearing) of exploratory behaviour of the rat. Effects of the age at which the sensory loss was produced and of the interval between sensory loss and testing were also investigated.

Some of the animals were subjected to sensory loss in infancy and were tested also in infancy (Y-Y condition), others were subjected to sensory loss in infancy but were tested at maturity (Y-M condition), and still others were subjected to sensory loss at maturity and were tested also at maturity (M-M condition). In each of these three conditions, the animals fell into four groups, blind, vibrissaeless, blind and vibrissaeless, and normal controls. The animals were observed in a test cage for ten minutes on each of three successive days and their walking and rearing responses recorded using a modified time-sample method.

The results suggest the following tentative conclusions. Exploratory activity in the rat, as measured by the frequency of occurrence of walking and rearing responses, is, in general, increased by sensory loss. Adult animals require a lesser amount of sensory loss to effect an increase in exploration than do young animals. The removal of vibrissae delays the emergence of rearing in the infant rat. The role of the interval between the infliction of sensory loss and tests of exploratory behaviour requires clarification.

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NOTE ON THE EFFECTS OF DIFFERENTIAL REARING CONDITIONS ON WEIGHT GAIN IN THE HOODED RAT[1]

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ALTHOUGH THERE IS A FAIRLY LARGE LITERATURE dealing with the effects of early experience on weight gain in rats, "gentling" (a special type of handling) is the only variable that has been extensively studied: other effects of early experience on weight gain have received scant attention. The present note concerns the effects of two variables, free *versus* restricted rearing environments and handling *versus* non-handling, on weight gain in the hooded rat.

Forty male hooded rats, obtained from the Royal Victoria Hospital colony at the age of three weeks, were randomly divided into four groups as follows: free-environment handled, free-environment non-handled, restricted handled, and restricted non-handled. Free-environment animals were housed in a large wire mesh cage which contained playthings and from which the rest of the room was visible. Restricted animals were housed in standard colony cages without playthings, and the doors and tops of the cages were covered with translucent white paper to prevent the animals from seeing out. Handled animals were removed from their cages once each day and stroked ten times, while non-handled animals were picked up briefly only once a week when their cages were cleaned. All animals were transferred to a uniform environment at the age of ten weeks.[3] The animals were maintained on an *ad lib.* diet of Purina Fox Chow pellets and water. After the initial weighing at 3 weeks, weights were recorded on seven separate occasions—at 6, 9, 10, 11, 12, 13, and 15 weeks of age; in order to minimize handling, this was done when the animals were removed for cage cleaning.

A $2 \times 2 \times 7$ correlated analysis of variance, with rearing, handling, and replications as the main effects, was carried out, and the results are shown in Table I. Rearing (but not handling) significantly affected weight gain ($p < .05$); restricted rats weighed more than free-environment rats and, as shown by the mean values in Table II, this trend was apparent at each of the seven weighings. Since all animals were gaining weight during the course of the experiment, one would expect to obtain a highly significant F ratio for replications and this, in fact, occurred. The failure to find a significant T $\times$ R interaction indicates that there was little

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[3]The apparatus and rearing conditions were fully described in a previous article (Ehrlich, 1959).

TABLE I

ANALYSIS OF VARIANCE OF WEIGHT GAIN IN RATS SUBJECTED TO DIFFERENTIAL REARING CONDITIONS

Source	*ss*	*df*	Mean square	*F*
Uncorrelated				
Between handling (H)	312.92	1	312.92	—
Between rearing (R)	19189.73	1	19189.73	6.22[a]
H × R	782.23	1	782.23	—
Within Groups	110942.70	36	3081.74	
Correlated				
Between trials (T)	713273.48	6	118878.91	1062.74[b]
T × H	588.58	6	98.09	—
T × R	877.17	6	146.19	1.30
T × H × R	724.17	6	120.69	1.07
Error (Pooled S × T)	24162.88	216	111.86	

[a] $p < .05$.
[b] $p < .01$.

TABLE II

MEAN WEIGHTS OF FREE-ENVIRONMENT AND RESTRICTED RATS

Condition	Age (weeks)	Restricted (grams)	Free-environment (grams)
Start of experiment	3	37	36
In rearing environments	6	136	124
	9	227	207
	10	244	225
In uniform environment	11	245	235
	12	273	257
	13	288	270
	15	306	285

difference between the measurements taken during and after the experimental treatment. To put this another way, one can say that the effect of the rearing environments was relatively long-lasting, a finding that is also shown by the mean values in Table II. Differences in weight between free-environment and restricted rats were still apparent five weeks after the animals had been removed from the rearing environments.

Although the reason for the difference found between free-environment and restricted rats is not clear, a tentative explanation in terms of social facilitation of eating behaviour may be offered. Both the restricted and free-environment animals were reared in groups in this experiment, but outside visual distraction was minimal in the restricted group and, therefore, cues from other animals were more likely to be effective in eliciting eating behaviour in the restricted group. Montgomery and Zimbardo's finding (1957) that rats reared singly under conditions of sensory and

behavioural restriction were not heavier than rats reared singly in normal cages lends some support to this explanation. Also their data would seem to rule out the possibility that the restricted rats in the present experiment were heavier because they had less space in which to move about.

The finding that handling did not affect weight gain is consistent with the results of Mogenson and Ehrlich (1958) who, using the same strain of rats, found that gentling had no effect on weight gain. Since gentled animals typically receive far more petting than was received by the handled animals in the present experiment, it is not surprising that, in this case, handling was found to produce no effect on weight gain.

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(First received February 23, 1961)

BOOK REVIEWS

Training for Research in Psychology: The Canadian Opinicon Conference, 1960. Edited by KARL S. BERNHARDT. Toronto: University of Toronto Press, 1961. Pp. x, 130. $4.00.

CANADIAN PSYCHOLOGY underwent a rapid expansion after the Second World War, and the supply of adequately trained psychologists has never kept up with the demand for professional psychologists to work in the applied fields. It has generally been accepted in Canada that the universities are the proper place to train professional psychologists, even though a good deal of the postgraduate instruction consists merely in teaching the student applied professional techniques. Most universities, however, continue to make the research project the major part of both the M.A. and Ph.D. degree. Some professional psychologists have opposed this on the grounds that it places an undue emphasis on research training, although original research is often not a part of the job for which the psychologist is being trained, and it leaves too little time for the acquisition of the needed practical skills. Some university psychologists, on the other hand, have strongly opposed this point of view, arguing that research must continue to be the main part of graduate work, and that applied professional skills in any event can be picked up on the job when the psychologist leaves the university.

As a result of this controversy, the Canadian Psychological Association, at their annual meeting in Edmonton in 1958, determined to hold a conference to discuss the future of psychology in Canada. A committee was duly set up, financial assistance was obtained from the National Research Council and from the Social Science Research Council of Canada, and the Opinicon Conference was organized. A Steering Committee chaired by R. B. Bromiley invited 39 psychologists to meet at Opinicon in the spring of 1960 for a week, and 34 were able to attend. The delegates included representatives from the Canadian universities, a roughly equal number of psychologists in non-university posts, and a representative from the United States. In addition seven "recorders," younger university teachers from Ontario and Quebec, were invited, both to record the discussions, and to represent the viewpoint of the younger Canadian psychologists. The discussions were carefully organized, some taking part in full meetings, and others in smaller groups. J. D. Ketchum was asked to give a keynote address to start the conference, and the discussions were introduced by seventeen prepared papers. Detailed records of all meetings were kept and, in addition, the conclusions of the conference

were formulated at the end of these sessions as a series of sixty-seven propositions which were then voted on by the entire conference. Fifteen of these were approved unanimously, thirty-five were approved by a majority, and the remainder were either rejected or supported by only half the delegates.

By the end of the conference the detailed proceedings thus represented a very considerable mass of material. At this point the conference made a very wise decision. The job of editing and preparing the proceedings of the conference for publication was left entirely in the hands of Karl S. Bernhardt who was given a free hand both to select what should be published, and to edit the discussion material and even the formal "propositions." In a relatively short time, Dr. Bernhardt has done an outstanding job. Verbatim transcripts of discussions are remarkably tedious to read after the event, when one is no longer buoyed up by the emotion of the moment, and when the many redundancies are merely distracting. Similarly, propositions hammered out word by word in discussion groups are generally inelegantly expressed, often verbose, and occasionally ungrammatical (as was recently re-discovered when the new authorized translation of the New Testament by a group of learned scholars was subjected to literary criticism). Dr. Bernhardt has managed to preserve the spirit of the discussions, and the point of the propositions, while at the same time expressing them smoothly and succinctly.

The original aim of the conference was to discuss the future of Canadian psychology, and in particular, the problems of professional training. This topic was thought to be too broad, so that the theme was in fact limited to "research and research training." Even so, much of the discussion had to do with the extent to which research training should be a major part of the professional training of all psychologists regardless of their specialty. The conclusions of the conference were quite unambiguous on this point. They strongly supported research training for all psychologists both at an undergraduate and at a graduate level. It is difficult to give a brief summary of all the sixty-seven propositions which represent the conclusions of the Opinicon meetings. Nevertheless these few quotations from those propositions which were accepted represent a definite and consistent point of view.

"The training of applied psychologists to fill service needs in their specific applied fields and/or to further knowledge in their field of interest should take place in psychology departments and should, at this stage of professional development, remain as fully integrated into the departmental programme as possible."

"We recognize the need of providing training in specific skills for the graduate in many fields of psychology—particularly in the professional field. This training will be integrated with training in research and scholarship in order to prepare the student for continued development without guidance after the Ph.D."

". . . the primary emphasis should be on research in the Ph.D. clinical programme . . . ."

"Since the improvement of psychological contributions to service is in part a function of research, it is important that service institutions should recognize their value in fostering research within the settings."

The conference felt that Ph.D. psychologists in service settings should continue to do research, and that, in order to free the necessary time, assistants at a subdoctoral level could be employed for giving the more routine services. It was concluded that more should be done to foster this image of the psychologist as a reasearch scientist in the mind of the lay public, since this would help to recruit into the profession the right sort of student.

This report will be of interest to every Canadian psychologist, and is certain to be widely read. It is likely to have a very considerable impact on university departments of psychology in view of the several carefully considered recommendations concerning both undergraduate and graduate psychology programmes which were supported by the large majority of those who were at Opinicon. However it should also be read by those who are responsible for employing professional psychologists in the applied fields, since it is clear that the conception of a professional psychologist by those at Opinicon is grossly discrepant with, for example, the routine psychometric testers sought by so many employing authorities.

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Psychoanalytic Concepts of Depression. By MYER MENDELSON, M.D. Springfield, Illinois: Charles C. Thomas [Toronto: The Ryerson Press], 1960. Pp. xii, 170.

EARLY IN HIS BOOK (p. 7), Mendelson reports a statement made in 1910 by Hoche who spoke of the Kraepelinians as giving "the impression of a great number of diligent workmen, most energetically engaged in clarifying a turbid fluid by pouring it busily from one vessel to another." This hoary statement could aptly be applied to those who have attempted to clarify the nature and genesis of depression.

The author's purpose in writing the book was to examine critically the concept of depression as it has evolved and as it prevails today. He writes from within the psychoanalytic framework and his standards for the acceptance of evidence are not those of most psychologists. This makes more significant the criticism contained in one of his concluding statements: "To one familiar with the open confessions of ignorance in other scientific disciplines it is a little disconcerting to read the confi-

dently proferred global conclusions of the literature on depression. This tendency to erect comprehensive theoretical systems makes it seem as if legitimate uncertainty has acquired the bar sinister" (p. 137).

Certainly it is clear that the workers in this field have not suffered from undue humility or been immobilized by inabilty to provide data to support statements of relationships.

We learn, for example, that the melancholic refuses to eat because he considers eating to be introjection of the (love) object and essentially an unconsciously hostile cannibalistic act; that the climax of the oral-libidinal gratification may be described as an "alimentary orgasm"; that the depressed child feels that all goodness and love and security are lost as a result of his own uncontrollable greedy and destructive phantasies and impulses against his mother's breasts; and so on.

Perhaps the most significant impression fostered by this book is that basically both psychoanalysis and psychiatry have remained static for the greater part of the past half century. The central issues which existed at the beginning of this century appear to vary little from contemporary issues. For example, Nissel is reported (p. 6) to have said in 1902: "In almost all the functional psychoses it is possible to demonstrate anatomical findings in the cortex. As soon as we agree to see in all mental derangements the clinical expression of definite disease processes of the cortex, we remove the obstacle which today makes impossible all agreement among alienists," And in 1908, Adolf Meyer was saying: "To try and explain a hysterical fit or a delusion system out of hypothetical cell alterations which we cannot reach or prove is at the present stage of histophysiology a gratuitous performance. To realize that such a reaction is a faulty response or substitution of an insufficient or protective or evasive or mutilated attempt at adjustment opens ways of inquiry in the direction of modifiable determining factors and all of a sudden we find ourselves in a live field, in harmony with our instincts of action, of prevention, of modification and of an understanding doing justice to a desire for directness instead of neurologizing tautology" (p. 8).

Passages like this make reading the book an interesting sortie into a part of the older psychiatric, and psychoanalytic, literature which most of us seldom pursue with any diligence. It is valuable in providing a perspective for the evaluation of current theory and practice not only as it concerns manic-depression but as it concerns psychiatry generally. Reading it should have a sobering influence on those who are excited about "the new breakthroughs" in the understanding and treatment of mental disorder.

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Children and Adolescents: Behavior and Development. By BOYD R. MCCANDLESS. New York: Holt, Rinehart and Winston, 1961. Pp. 521.

CHILD DEVELOPMENT RESEARCH LITERATURE has been accumulating rapidly in the last twenty years. This scattered, fragmentary material can be confusing and even misleading to the student. It needs to be correlated, evaluated, and interpreted. This is what Dr. McCandless has attempted with some success. This is a book which should prove to be a valuable guide to some of the important research on child development.

As the author says in the Preface, the book is selective. One can agree readily with his contention that it is impossible for a child psychologist to embrace all the research and all the theory that has been amassed about the development and behaviour of children and adults. However, it is easy to quarrel about the selection and especially about the omissions. There is very little on language development, emotions, cognitive development (Piaget is not even mentioned), or moral and character development. Although adolescents are mentioned in the title, there is not much space devoted to the adolescent period as such. Perhaps we should be content with the author's contention that "the principles of behaviour relevant to the child of 11 hold equally well for the child who has turned 14." However, the developmental approach, in which an appreciation of the continuous growth of independence and the process of emancipation from adult direction is not given much attention. There are enormous differences in the behaviour of a very young child and a near-adult which are not very apparent in the book.

I suppose no one is ever completely satisfied with a book dealing with his own special area of interest. There are usually aspects of it which he would like changed. However, after getting over some minor disappointments, I find that I can become enthusiastic about McCandless's book. This is not another manual merely summarizing research. Nor is it the usual kind of textbook offering a systematic summary of what is known about child development. It is an exposition of some areas. Probably the topics selected are those in which the author is most interested and with which he is most familiar. There is a refreshing attempt to be "down to earth" and the reader gets the feeling that the material has relevance to live people and that the results of research are meant to be used by parents and teachers.

The book is organized into fourteen chapters, a brief description of which may indicate the nature of the material handled. (1) "Culture and human behaviour" provides a brief rather superficial discussion of culture, moves to motherhood and infant care, and then outlines the sensory equipment of the child. (2) "Methods and problems in the study of child-

rearing practices" is a very useful discussion of methodology and theoretical framework. (3) "Child-rearing practices" summarizes the major studies on training in feeding and weaning, elimination, sex, dependency, and aggression. (4) "Learning and motivation" is a useful exposition of the Hullian theory of learning. (5) "Special factors in human learning" includes discussions of expectancy and probability, curiosity, fixation, approach and avoidance, conflict, displacement, and sublimation and compensation. (6) "The self-concept" is a valuable summary of research in this area. (7) "Intelligence: measurement and educational practices" assesses the use of intelligence tests from infancy to adulthood. (8) "Sources of variation in measured intelligence" summarizes the research on factors related to intelligence. (9) "Physical growth and motor development" is a useful summary with possibly too much space given to body types. (10) "Socialization, sex-typing and identification" presents theory and some research results. (11) "Authoritarianism and prejudice" reviews theory and research illustrating the development of beliefs and predispositions in children. (12) "The development of authoritarian personalities" deals with child-rearing practices, social class, and the authoritarian personality. (13) "Child development and childhood education" relates material on level of aspiration, achievement, motivation, frustration, and failure to the school. (14) "The middle-class teacher and the 'every-class' child" deals with the relations between social class and school practices.

This is not just another book on child psychology. It is a serious attempt to bring together a considerable body of theory and research results and to evaluate them as a basis for the understanding of children. It is a valuable addition to the serious literature in this field.

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Variations in Value Orientations. By FLORENCE ROCKWOOD-KLUCKHOHN & FRED L. STRODTBECK. Evanston, Illinois: Row Peterson, 1961. Pp. xiv, 437.

THIS BOOK has multiple authorship. To the names of the two senior authors, the title page adds the names of four "assistant authors," John M. Roberts, A. Kimball Romney, Clyde Kluckhohn, and Harry A. Scarr. The result might have been a hodge-podge of bits and pieces, but for the obviously dominant influence of F. Kluckhohn who has clearly exerted a unifying, but not stultifying, influence over all the contributors.

The plan of the book is laid out on spacious lines for these days of high publishing costs. F. Kluckhohn's introductory chapter on the theory of dominant and variant value orientations is followed by chapters describing the five communities studied (Zuni, Navaho, Spanish-American, Mormon, Texan), the research instrument (F. Kluckhohn's values schedule of twenty-two items), and the statistical methods of analysing the data. Four additional chapters discuss the validity of the schedule results with reference to field data and previous information collected about the five communities. A final chapter restates the theory and discusses some of its more important implications. Four Appendices conclude the book. They give the Spanish-language version of the schedule, further notes on the method of graphic analysis of ranked value preferences, a study of value consensus, and a final twenty-one-page table that presents the rank ordering by each respondent in the five communities of every item in the value schedule.

The whole report is not only unique in its ample coverage of discussion, raw material, and methodological analysis. It is also exceptional in the way it records a process of theoretical and empirical enquiry that has been going on for at least twenty years. No one can complain, in days that often witness the publication of many pieces of ill-designed and hastily carried out research, that this particular piece of work has not been well thought over before publication. It is true that knowledgeable researchers have occasionally and privately expressed impatience over the time taken to develop and publish this work. Their patience has now been rewarded by a report that is magisterial in its scope and detail.

The theory of value orientations (expressed more clearly for the newcomer in chapter X, "Summary and Discussion," than in chapter I, where the lay-out of the theory tends to become at times confused by excursions into interesting by-ways) asserts most simply that human beings solve common human problems by the aid of those ordering and directing principles called value orientations. Every culture operates in terms of a set of dominant values together with an interrelated set of permitted or required variant values. Cultures can therefore be studied for both their cross-cultural use of these values and for within-culture variations. In New Mexico, F. Kluckhohn found the natural laboratory that has enabled her to put this theory of human behaviour to the test of empirical enquiry: five different cultures, each with markedly different traditions, history, economic life, social structures, and religions, inhabiting approximately the same geographical area. If value orientations order and direct human behaviour, proof should be found in this area. Answers to the value-orientations schedule, subjected to suitable statistical analysis, appear without doubt to substantiate the case.

It is a fairly safe prediction that this report will become a classic in social science research. It is closely argued and not easy to read quickly. But it contains a wealth of suggestive ideas and implications for developing many of the contemporary frontiers in behavioural research. We may agree or disagree when F. Kluckhohn claims for her theory of value orientations, "an independent status in studies of human behaviour" (p. 363). What this claim means I do not quite know. But at least it is clear that much valuable cross-cultural behavioural research is likely to be stimulated by the theory and method described in this book.

ERNEST BEAGLEHOLE

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